Bulletin 594

# Ohio Erosion Control and Sediment Pollution Abatement Guide



## for Agricultural Land

CONTROL STRUCTURES

CONSERVATION TILLAGE

GRASSED WATERWAYS

DIVERSION TERRACE

SEEDED DRAINAGE DITCH

COOPERATIVE EXTENSION SERVICE / THE OHIO STATE UNIVERSITY

## ON THE COVER

**A badly eroded field is shown on the cover's center circle. Measures to prevent such erosion are shown in the photos under that circle.**

**Cooperative Extension Service, The Ohio State University**
**Division of Soil and Water Districts and Division of Lands and Soil,**
**Ohio Department of Natural Resources**
**Ohio Agricultural Research and Development Center**
**USDA Soil Conservation Service (Provided information and technical data)**

## CONTENTS



**Committee of Authors**

Samuel W. Bone
Extension Agronomist
Cooperative Extension Service

Richard Christman
Assistant Chief
Division of Lands and Soil

LaVern M. Feusner
Agronomist
Soil Conservation Service

Robert L. Goettemoeller
Deputy Chief
Division of Soil and Water Districts

Byron H. Nolte, Committee Chairman
Extension Agricultural Engineer
Cooperative Extension Service

# OHIO EROSION CONTROL AND SEDIMENT POLLUTION ABATEMENT GUIDE

(FOR AGRICULTURAL LAND)

## PREFACE

Agricultural pollution abatement laws enacted by the Ohio General Assembly in 1972, were amended, effective January 12, 1979. These laws define "Agricultural Pollution" as failure to use management or conservation practices in farming or silvicultural operations to abate wind or water erosion of the soil or degradation of waters of the state by animal waste or soil sediment including attached substances. These laws require the Chief of the Division of Soil and Water Districts, Ohio Department of Natural Resources to establish standards to achieve a reasonable level of management and conservation on agricultural land. The Division will work through cooperative agreements with local soil and water conservation districts and other agricultural service agencies to seek compliance with the state standards. The Director of the Ohio Environmental Protection Agency is instructed to work with the Division of Soil and Water Districts and local conservation districts in encouraging the abatement of agricultural pollution. (Ohio Revised Code, Section 1515.01, 1515.08, 1501.20, 1515.30 and 1515.31).

The laws also authorize the state to share the cost of installing agricultural pollution abatement practices which require capital expenditures that are likely to exceed the economic returns to the landowner or operator. The Division of Soil and Water Districts will coordinate the cost share program with similar federal programs and implement it through the local soil and water conservation districts.

Soil loss tolerances listed in this guide are upper limits of soil loss with regard to maintaining soil productivity — a goal equally as important as maintaining or improving water quality. This guide includes methods and procedures for determing probable soil losses from farm land and for determining soil and water management practices to keep average annual soil losses below the tolerable losses. There has not been enough research to develop predictions of water quality for a specific site based on soil erosion estimates.

## PURPOSE OF GUIDE

This guide (1) outlines a procedure for estimating the rate of water erosion on agricultural land, (2) lists maximum soil erosion tolerances, (3) gives cropping-management and conservation practice alternatives for water erosion control, (4) lists recommended practices for erosion control on nearly level land, (5) outlines a procedure for estimating wind erosion of sandy soils, (6) suggests maximum rates of wind erosion that should be allowed for various soils and crops, and (7) gives cropping-management and conservation practice alternatives for wind erosion control.

Information required to use the guide include the soil series; field location, county; land slope, steepness and length; cropping-management system; and conservation practices applied.

## INTRODUCTION

### Water Erosion:

Soil erosion by water is the dominant hazard on about 48 percent of Ohio agricultural land. Sixty-four percent of the soil loss from agricultural land is from cropland, 21 percent from forest land and 15 percent from pasture.

Estimated annual soil loss on cropland ranges from less than 1 ton per acre per year on nearly level cropland and up to 13 tons per acre per year on 12-18 percent slope cropland (SCS Erosion Inventory, 1977). Tolerable average annual soil loss ranges from 1 to 5 tons per acre per year for Ohio soils. Productivity can be maintained or increased if soil loss is kept below allowable limits (soil loss tolerance factors).

Excessive soil loss results in soil structure damage and increased crusting problems, reduced crop yields due to plant nutrient loss, and loss of available water to plants by reduction of the water holding capacity of the soil. The soil lost may be deposited further down the slope, in drainage ditches, streams, lakes and harbors. The sediment may lower water quality or require removal in order to restore adequate drainage, flood control or navigation.

Types of water erosion include soil detachment, sheet erosion and rill erosion.

*Soil detachment* is the breakdown of soil aggregates and the scattering of small soil particles by falling raindrops. It is the first step in water erosion and the formation of soil crusts. The formation of a crust results in reduced ability of the soil to absorb water, and consequently, more runoff and erosion.

*Sheet erosion* is the removal of a uniform layer of soil material from the surface by flowing water. The soil particles detached are carried away. The particles in moving water act as abrasives in detaching additional particles from the soil mass. Sheet erosion is not easily recognized, but often removes 3-5 tons of soil per acre per year.

*Rill erosion* is the removal of soil particles by water flowing in small channels or between rows. These rills are less than an inch deep and do not interfere with normal tillage operations. However, this erosion may result in movement of 7-10 tons of soil per acre per year.

### Wind Erosion:

Wind erosion can be another source of sediment pollution, resulting in fine particles of soil material being removed from the soil surface and carried by the wind. This results in severe crop damage, soil loss, air pollution, and off-site soil deposits.

Wind erosion damage has been increasing on the wind-erodible soils in northwestern Ohio. These are primarily the sandy soils of the flat lakebed region, but also include areas of organic soils and fine-textured clay soils with finely aggregated surfaces throughout the state.

Studies on sandy-textured soils in northwestern Ohio have shown soil losses caused by wind erosion as high as 130 tons per acre during a severe windstorm. Crop damage to susceptible vegetable crops can result from soil losses of as little as one-half ton per acre per year or less.

## WATER EROSION

### EROSION FACTORS AND THEIR CONTROL ON SLOPING LAND

Nearly 60 percent of the agricultural land in Ohio has slopes greater than two percent, which can erode if not properly managed.

Water erosion is affected by several factors: rainfall intensity and duration, soil erodibility, length and steepness of slope, vegetative cover, soil management practices, and erosion control practices. These factors have been combined by scientists (Wischmeier and Smith, 1978) into a **universal soil loss equation**, for predicting soil losses from a given soil. The equation is based on years of research and field experience with soil erosion and runoff throughout the eastern U.S., and is being refined and improved in accuracy as more data and experience with its use become available. Because of the extensive local data available for use in the equation, it has general applicability on most upland soils in this region. Briefly, the equation is as follows:

$$A = R \times K \times LS \times C \times P$$

where: A is the computed soil loss in tons per acre per year, R - the rainfall factor, K - the soil erodibility factor, LS - the slope length and steepness factor, C - the cropping-management factor, and P - the erosion control practice factor.

Numerical values for each of the six factors in the equation were determined from research data and vary from one locality to another. Reference tables of these values have been developed to predict soil losses under a given set of conditions, and to select that combination of practices and management systems to meet a soil loss limit.

Research in Ohio has helped develop values for the various factors in the soil loss equation for Ohio conditions. This allows use of the equation to help plan proper soil erosion control programs. Some of the information on the soil loss factors in Ohio are as follows:

### Rainfall (R):

The relative erosion potential of rainfall over Ohio varies less than 20 percent as shown in Figure 1. The values shown are a measure of the average annual energy of all rainfall. The R factors range from 175 at Cincinnati to about 110 near Toledo. Erosion of bare soil by months is shown in Table 1.

**TABLE 1: Percent of Annual Erosion by Months***

| Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 2 | 4 | 6 | 10 | 20 | 20 | 14 | 10 | 6 | 4 | 2 |

*Applicable for bare medium textured Ohio Soil on slopes greater than 2%, does not apply to fine textured soils of northwestern Ohio.

## Soil Erodibility (K):

From direct soil loss measurements on selected soils, the relative erodibility has been determined for most soil types in tons per acre per unit of rainfall erosion potential. The soil erodibility or K value for Ohio soils ranges from 0.17 for sandy soils (for example, Spinks) to 0.49 for some highly erodible medium textured soils (for example, Canadice). The complete table of K values is listed in Table 2.

**FIGURE 1: Average Annual Values of the Rainfall Factor, R. USDA Agr. Handbook No. 537, 1978**

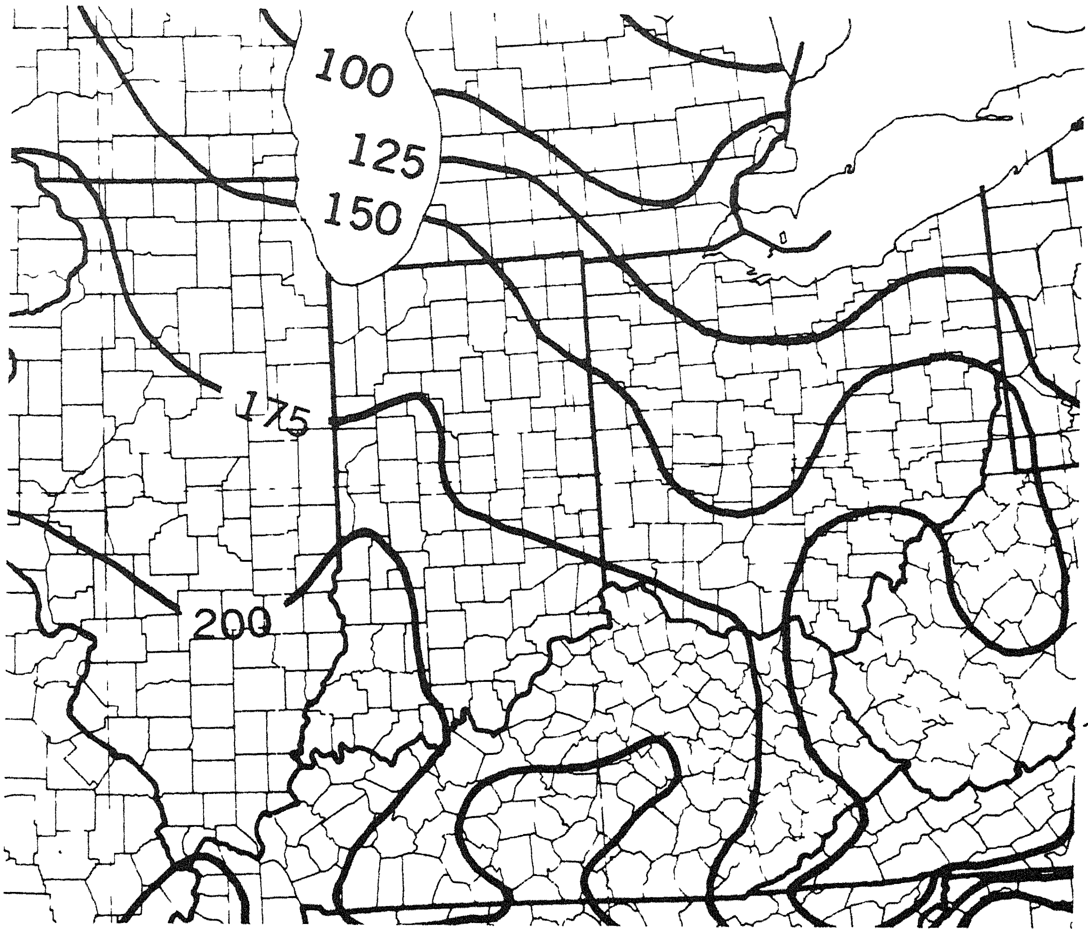



**TABLE 2: K and T Values for Ohio Soil Series**

K values are the soil erodibility factor for use in the universal soil loss equation and T values are soil loss tolerance factors for wind and water erosion.

The first number under the T column below is to be used in resource planning with those soils that have a slight or moderate degree of erosion. The second number is to be used with soils that have a severe degree of erosion.

| Soil Series | K | T | Soil Series | K | T | Soil Series | K | T | Soil Series | K | T |
|---|---|---|---|---|---|---|---|---|---|---|---|
| [1]Abington | .32 | 5-5 | Arkport | .32 | 3-2 | Belmore | .32 | 4-3 | Bogart | .32 | 5-4 |
| [1]Abscota | .17 | 5-5 | Ashton | .28 | 4-3 | Belpre | .32 | 5-4 | [1]Bono | .28 | 5-5 |
| [2]Adrian | - | - | [1]Atherton | .37 | 5-5 | Bennington | .43 | 3-2 | [1]Bonpas | .28 | 5-5 |
| Alexandria | .37 | 5-4 | [1]Atkins | .37 | 5-5 | Bentonville | .43 | 3-2 | Boston | .37 | 3-2 |
| Alford | .37 | 5-4 | [1]Atlas | .43 | 3-2 | Berks | .24 | 3-2 | Boyer | .17 | 4-3 |
| [1]Algansee | .17 | 5-5 | Avonburg | .43 | 4-3 | Bethesda | .32 | 5-5 | Braceville | .24 | 3-2 |
| [1]Algiers | .37 | 5-5 | Barkcamp | .24 | 5-5 | [3]Bethesda | .43 | 5-5 | Bratton | .37 | 4-3 |
| Allegheny | .32 | 4-3 | [3]Barkcamp | .32 | 5-5 | Birkbeck | .37 | 5-4 | Brecksville | .43 | 4-3 |
| Allis | .43 | 3-2 | Bartle | .43 | 4-3 | [1]Blanchester | .37 | 5-5 | Brenton | .28 | 5-4 |
| Alvin | .24 | 5-4 | Beasley | .43 | 3-2 | Blount | .43 | 3-2 | Bronson | .17 | 5-4 |

## TABLE 2: K and T Values for Ohio Soil Series

| Soil Series | K | T |
|---|---|---|
| Brooke | .43 | 3-2 |
| Brookside | .37 | 5-4 |
| [1]Brookston | .28 | 5-5 |
| Broughton | .43 | 3-2 |
| Cambridge | .43 | 4-3 |
| Cana | .37 | 4-3 |
| Canadice | .49 | 5-5 |
| Caneadea | .43 | 3-2 |
| Canfield | .37 | 4-3 |
| Captina | .43 | 3-2 |
| Cardington | .37 | 5-4 |
| Carlisle | - | - |
| Casco | .32 | 3-2 |
| Castalia | .20 | 2-1 |
| Cavode | .43 | 3-2 |
| Celina | .37 | 5-4 |
| [1]Ceresco | .20 | 5-5 |
| [1]Chagrin | .32 | 5-5 |
| Channahon | .37 | 2-1 |
| Chenango | .32 | 3-2 |
| Chili | .32 | 4-3 |
| [1]Chilo | .28 | 5-5 |
| [1]Chippewa | .32 | 3-3 |
| Cincinnati | .37 | 4-3 |
| Clarksburg | .37 | 3-2 |
| Claverack | .28 | 3-2 |
| Clermont | .37 | 5-4 |
| Clymer | .28 | 3-2 |
| [1]Cohoctah | .28 | 5-5 |
| Colonie | .24 | 4-3 |
| [1]Colwood | .28 | 5-5 |
| Colyer | .32 | 2-1 |
| [1]Condit | .37 | 5-4 |
| [1]Conneaut | .37 | 4-4 |
| Conotton | .24 | 3-2 |
| Coolville | .43 | 4-3 |
| Corwin | .28 | 5-4 |
| Coshocton | .37 | 4-3 |
| Crane | .28 | 5-4 |
| Crider | .32 | 4-3 |
| Crosby | .43 | 3-2 |
| Cruze | .37 | 3-2 |
| Culleoka | .32 | 3-2 |
| [1]Damascus | .32 | 5-5 |
| Dana | .32 | 5-4 |
| Darien | .37 | 3-2 |
| Darroch | .32 | 5-4 |
| [1]Defiance | .37 | 5-5 |
| Dekalb | .24 | 3-2 |
| [1]Delmar | .37 | 4-3 |
| Del Rey | .43 | 3-2 |
| Digby | .32 | 4-3 |
| Dubois | .43 | 4-3 |
| Dunbridge | .17 | 4-3 |
| Duncannon | .43 | 3-2 |
| [1]Dunning | .37 | 5-5 |
| Eden | .43 | 3-2 |
| Edenton | .43 | 3-2 |
| [2]Edwards | - | - |
| [1]Eel | .37 | 5-5 |
| Elba | .43 | 3-2 |
| Eldean | .37 | 4-3 |
| Elkinsville | .37 | 5-5 |
| Elliott | .28 | 4-4 |
| Ellsberry | .37 | 3-2 |
| Ellsworth | .43 | 3-2 |
| Elnora | .24 | 4-3 |
| Enoch | .28 | 5-5 |
| [3]Enoch | .37 | 5-5 |
| Ernest | .43 | 3-2 |
| Euclid | .37 | 5-5 |
| Fairmount | .37 | 2-1 |
| Fairpoint | .37 | 5-5 |
| [3]Fairpoint | .43 | 5-5 |
| Fawcett | .43 | 3-2 |
| Fincastle | .37 | 5-4 |
| Fitchville | .37 | 5-4 |
| Fox | .37 | 4-3 |
| Frenchtown | .37 | 3-2 |
| [1]Fries | .28 | 5-5 |
| Fulton | .43 | 3-2 |
| Galen | .28 | 3-2 |
| Gallia | .37 | 5-4 |
| Gallman | .32 | 5-4 |
| Gasconade | .20 | 2-2 |
| Geeburg | .43 | 3-2 |
| [1]Genesee | .37 | 5-5 |
| [1]Gilford | .20 | 5-5 |
| Gilpin | .28 | 3-2 |
| Ginat | .43 | 4-3 |
| Glenford | .37 | 5-4 |
| [1]Glynwood | .43 | 3-2 |
| Gosport | .43 | 3-2 |
| [1]Granby | .17 | 5-5 |
| Grayford | .37 | 5-4 |
| Gresham | .37 | 4-3 |
| Guernsey | .43 | 3-2 |
| Hackers | .28 | 4-3 |
| Hagerstown | .32 | 4-3 |
| Haney | .28 | 4-3 |
| Hanover | .37 | 5-4 |
| [1]Hartshorn | .32 | 3-2 |
| Haskins | .37 | 4-3 |
| Haubstadt | .43 | 3-2 |
| [1]Hayter | .28 | 4-4 |
| Hazelton | .17 | 4-3 |
| Heitt | .37 | 3-2 |
| Hennepin | .32 | 5-4 |
| Henshaw | .43 | 4-3 |
| Hickory | .37 | 5-4 |
| [1]Holly | .28 | 5-5 |
| Homer | .37 | 4-3 |
| Hornell | .43 | 3-2 |
| Hoytville | .28 | 5-5 |
| [1]Huntington | .32 | 5-5 |
| Ilion | .37 | 3-2 |
| Ionia | .24 | 4-3 |
| Iva | .43 | 4-3 |
| Jacksonville | .43 | 4-3 |
| Jessup | .43 | 3-2 |
| Jimtown | .32 | 4-3 |
| Johnsburg | .43 | 3-2 |
| [1]Joliet | .28 | 3-2 |
| Kalamazoo | .32 | 4-3 |
| Kane | .28 | 4-3 |
| Keene | .37 | 4-3 |
| Kendallville | .37 | 3-2 |
| [2]Kerston | - | - |
| Kibbie | .28 | 5-4 |
| [1]Killbuck | .37 | 5-5 |
| [1]Kings | .28 | 5-5 |
| Kingsville | .24 | 5-4 |
| [1]Kokomo | .32 | 3-3 |
| Laidig | .28 | 4-3 |
| Lakin | .17 | 5-5 |
| Lamson | .28 | 5-5 |
| Landes | .20 | 5-5 |
| Lanier | .20 | 5-5 |
| Latham | .43 | 3-2 |
| Latty | .28 | 5-5 |
| Lawrence | .43 | 3-2 |
| Lawshe | .32 | 3-2 |
| [1]Lenawee | .28 | 4-4 |
| Lewisburg | .43 | 3-2 |
| Library | .43 | 3-2 |
| Licking | .43 | 3-2 |
| [1]Lindside | .28 | 3-2 |
| [2]Linwood | - | - |
| [1]Lippincott | .28 | 5-5 |
| [1]Lobdell | .37 | 5-5 |
| Lockport | .43 | 3-2 |
| [1]Lorain | .32 | 5-5 |
| Lordstown | .20 | 3-2 |
| Lorenzo | .28 | 3-2 |
| Loudon | .43 | 3-2 |
| Loudonville | .32 | 4-3 |
| Lowell | .37 | 3-2 |
| Lucas | .43 | 3-2 |
| Luray | .32 | 5-5 |
| Lykens | .37 | 4-3 |
| Mahalasville | .28 | 5-5 |
| Mahoning | .43 | 3-2 |
| [1]Marengo | .28 | 5-5 |
| Markland | .43 | 3-2 |
| Martinsville | .37 | 5-4 |
| [2]Martisco | - | - |
| McGary | .43 | 3-2 |
| [1]Medway | .32 | 5-5 |
| [1]Melvin | .24 | 5-5 |
| Mentor | .37 | 5-4 |
| [1]Mermill | .28 | 5-5 |
| Metea | .17 | 5-4 |
| Miami | .37 | 5-4 |
| Miamian | .37 | 5-4 |
| Milford | .28 | 5-5 |
| [1]Millgrove | .28 | 5-5 |
| [1]Millsdale | .32 | 4-4 |
| Milton | .37 | 4-3 |
| [1]Miner | .32 | 5-5 |
| Mitiwanga | .32 | 4-3 |
| Monongahela | .43 | 3-2 |
| [1]Monroeville | .32 | 5-5 |
| [1]Montgomery | .37 | 5-5 |
| Morley | .43 | 3-2 |
| Morristown | .32 | 5-5 |
| [3]Morristown | .43 | 5-5 |
| [1]Moshannon | .37 | 5-5 |
| Muse | .37 | 3-2 |
| [2]Muskego | - | - |
| Muskingum | .28 | 3-2 |
| Nappanee | .43 | 3-2 |
| Negley | .32 | 3-2 |
| Neotoma | .20 | 3-2 |
| [1]Newark | .32 | 5-5 |
| Nicholson | .43 | 3-2 |
| [1]Nolin | .43 | 5-5 |
| Oakville | .15 | 5-5 |
| Ockley | .37 | 5-4 |
| Odell | .32 | 5-4 |
| [2]Olentangy | - | - |
| Olmsted | .24 | 5-5 |
| Opequon | .43 | 2-1 |
| [1]Orrville | .37 | 5-5 |
| Oshtemo | .24 | 5-4 |
| Otisville | .17 | 3-2 |
| Ottokee | .17 | 5-5 |
| Otwell | .43 | 3-2 |
| Painesville | .24 | 4-3 |
| Pandora | .37 | 5-4 |
| [1]Papakating | .28 | 5-5 |
| Parke | .37 | 5-4 |
| Parr | .32 | 5-4 |
| [1]Patton | .28 | 5-5 |
| [1]Paulding | .28 | 5-5 |
| Pekin | .43 | 4-3 |
| [1]Peoga | .43 | 5-4 |
| [1]Pewamo | .24 | 4-4 |
| [1]Philo | .32 | 5-5 |
| Pierpont | .43 | 4-3 |
| Pike | .37 | 5-4 |
| Plainfield | .17 | 5-5 |
| Platea | .43 | 3-2 |
| Plattville | .32 | 5-4 |
| [1]Pope | .32 | 5-5 |
| Princeton | .24 | 5-4 |
| Prout | .28 | 4-3 |
| Purdy | .43 | 3-2 |
| Pyrmont | .43 | 3-2 |
| [1]Ragsdale | .28 | 5-5 |
| Rainsboro | .43 | 4-3 |
| Ramsey | .17 | 1-1 |
| Randolph | .37 | 3-2 |
| Rarden | .43 | 3-2 |
| Raub | .37 | 3-2 |
| Ravenna | .37 | 3-2 |
| Rawson | .32 | 4-3 |
| Rayne | .28 | 4-3 |
| Red Hook | .32 | 3-2 |
| Reesville | .37 | 5-4 |
| Remsen | .43 | 3-2 |
| [1]Reynolds | .24 | 4-4 |
| [2]Rifle | - | - |
| Rimer | .17 | 4-3 |
| Ritchey | .37 | 2-1 |
| Rittman | .43 | 4-3 |
| Rodman | .20 | 3-2 |
| Romeo | .37 | 1-1 |
| Roselms | .43 | 3-2 |
| [1]Ross | .32 | 5-5 |
| Rossmoyne | .37 | 4-3 |
| Rush | .37 | 5-4 |
| Russell | .37 | 5-4 |
| Sardinia | .37 | 5-4 |
| Schaffenaker | .17 | 3-3 |
| Sciotoville | .37 | 4-3 |
| [1]Sebring | .37 | 5-5 |
| Sees | .37 | 3-2 |
| Selfridge | .15 | 5-4 |
| [1]Senecaville | .32 | 5-5 |
| Seward | .17 | 4-3 |

| | | |
|---|---|---|
| Sheffield | .37 | 4-3 |
| Shinrock | .37 | 3-2 |
| [1]Shoals | .37 | 5-5 |
| Sisson | .24 | 5-4 |
| [1]Sleeth | .32 | 5-4 |
| [1]Sloan | .37 | 5-5 |
| Sparta | .17 | 5-5 |
| Spinks | .17 | 5-5 |
| St. Clair | .37 | 3-2 |
| Stafford | .24 | 4-3 |
| [1]Stendal | .37 | 5-5 |
| Stonelick | .24 | 5-5 |
| Summitville | .37 | 3-2 |
| Swanton | .32 | 3-2 |
| [1]Taggart | .37 | 5-4 |
| [2]Tawas | - | - |
| Tedrow | .17 | 5-5 |
| Thackery | .37 | 4-3 |
| Tilsit | .43 | 3-2 |
| [1]Tioga | .28 | 5-5 |
| Tippecanoe | .32 | 5-4 |
| Tiro | .37 | 4-3 |
| Titusville | .37 | 4-3 |
| [1]Toledo | .28 | 5-5 |
| Trappist | .37 | 3-2 |
| Trumbull | .37 | 3-2 |
| Tuscarawas | .28 | 4-3 |
| Tuscola | .24 | 5-4 |
| Tygart | .43 | 3-2 |
| Tyler | .43 | 3-2 |
| Tyner | .17 | 5-5 |
| Uniontown | .37 | 4-3 |
| Upshur | .43 | 3-2 |
| Vandalia | .37 | 4-3 |
| Vaughnsville | .32 | 4-3 |
| Venango | .37 | 4-3 |
| Vincent | .43 | 3-2 |
| [1]Wabasha | .32 | 5-5 |
| Wadsworth | .43 | 4-3 |
| Wallington | .49 | 3-2 |
| [1]Wallkill | .32 | 5-5 |
| [1]Warners | .43 | 5-5 |
| Warsaw | .28 | 4-3 |
| Washtenaw | .37 | 5-5 |
| Watertown | .17 | 4-4 |
| [1]Wauseon | .20 | 5-5 |
| Wayland | .32 | 5-5 |
| Wea | .32 | 5-4 |
| Weikert | .28 | 2-1 |
| Weinbach | .43 | 4-3 |
| Wellston | .37 | 4-3 |
| [1]Westland | .28 | 5-5 |
| Westmore | .37 | 4-3 |
| Westmoreland | .37 | 3-2 |
| [1]Wetzel | .37 | 5-5 |
| Wharton | .32 | 3-2 |
| Wheeling | .32 | 4-3 |
| [2]Willette | - | - |
| Williamsburg | .32 | 5-4 |
| Williamson | .49 | 3-2 |
| Wilmer | .28 | 5-4 |
| Woodsfield | .43 | 3-2 |
| Woolper | .37 | 3-2 |
| Wooster | .37 | 4-3 |
| Wynn | .37 | 4-3 |
| Xenia | .37 | 5-4 |
| Zaleski | .37 | 5-4 |
| Zanesville | .37 | 3-2 |

[1] Nearly level soils. K Values estimated.
[2] Organic soils. No K or T values are assigned.
[3] Reclaimed.
Note: The soil erodibility factors (K) are rounded to the following:
.15, .17, .20, .24, .28, .32, .37, .43, .49

## Slope Length and Steepness (LS):

Slope length and steepness are two important factors that affect erosion. A relative value of 1.0 has been arbitrarily assigned to a 9% slope with a length of 73 feet. The effects of slope length and steepness have been combined into LS values as shown in Table 3. These LS values vary as shown in the table. For example, a 5% slope 100 feet in length has an LS value of 0.54, while a 14% slope 300 feet in length has an LS value of 4.0.

**TABLE 3. Slope Length and Steepness Factor (LS)**

| LENGTH OF SLOPE (L) | Percent Slope (S) 0.5 | 1.0 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 8.0 | 10.0 | 12.0 | 14.0 | 16.0 | 18.0 | 20.0 | 30.0 | 40.0 | 50.0 | 60.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20 | .06 | .08 | .12 | .18 | .21 | .24 | .30 | .44 | .61 | .81 | 1.0 | 1.2 | 1.6 | 1.8 | 3.5 | 5.5 | 8 | 10 |
| 40 | .08 | .10 | .15 | .22 | .28 | .34 | .43 | .63 | .87 | 1.2 | 1.4 | 1.8 | 2.2 | 2.6 | 5.0 | 8 | 11 | 15 |
| 60 | .08 | .11 | .17 | .25 | .33 | .41 | .52 | .77 | 1.0 | 1.4 | 1.8 | 2.2 | 2.6 | 3.0 | 6.0 | 10 | 14 | 18 |
| 80 | .09 | .12 | .19 | .27 | .37 | .48 | .60 | .98 | 1.2 | 1.6 | 2.0 | 2.6 | 3.0 | 3.5 | 7 | 11 | 16 | 21 |
| 100 | .10 | .13 | .20 | .29 | .40 | .54 | .67 | .99 | 1.4 | 1.8 | 2.2 | 2.8 | 3.5 | 4.0 | 8 | 13 | 18 | 23 |
| 110 | .10 | .13 | .21 | .30 | .42 | .56 | .71 | 1.0 | 1.4 | 1.8 | 2.4 | 3.0 | 3.5 | 4.5 | 8 | 13 | 19 | 24 |
| 120 | .10 | .14 | .21 | .30 | .43 | .59 | .74 | 1.0 | 1.6 | 2.0 | 2.6 | 3.0 | 4.0 | 4.5 | 9 | 14 | 20 | 25 |
| 130 | .11 | .14 | .22 | .31 | .44 | .61 | .77 | 1.2 | 1.6 | 2.0 | 2.6 | 3.0 | 4.0 | 4.5 | 9 | 14 | 20 | 26 |
| 140 | .11 | .14 | .22 | .32 | .46 | .63 | .80 | 1.2 | 1.6 | 2.2 | 2.8 | 3.5 | 4.0 | 5.0 | 9 | 15 | 21 | 27 |
| 150 | .11 | .15 | .23 | .32 | .47 | .66 | .82 | 1.2 | 1.6 | 2.2 | 2.8 | 3.5 | 4.0 | 5.0 | 10 | 15 | 22 | 28 |
| 160 | .11 | .15 | .23 | .33 | .48 | .68 | .85 | 1.2 | 1.8 | 2.2 | 3.0 | 3.5 | 4.5 | 5.0 | 10 | 16 | 23 | 29 |
| 180 | .12 | .15 | .24 | .34 | .51 | .72 | .90 | 1.4 | 1.8 | 2.4 | 3.0 | 4.0 | 4.5 | 5.5 | 11 | 17 | 24 | 31 |
| 200 | .12 | .16 | .25 | .35 | .53 | .76 | .95 | 1.4 | 2.0 | 2.6 | 3.0 | 4.0 | 5.0 | 6.0 | 11 | 18 | 25 | 33 |
| 300 | .14 | .18 | .28 | .40 | .62 | .93 | 1.2 | 1.8 | 2.4 | 3.0 | 4.0 | 5.0 | 6.0 | 7 | 14 | 22 | 31 | 40 |
| 400 | .15 | .20 | .31 | .44 | .70 | 1.0 | 1.4 | 2.0 | 2.8 | 3.5 | 4.5 | 5.5 | 7 | 8 | 16 | 25 | 36 | 46 |
| 500 | .16 | .21 | .33 | .47 | .76 | 1.2 | 1.6 | 2.2 | 3.0 | 4.0 | 5.0 | 6.0 | 8 | 9 | 18 | 28 | 40 | 52 |
| 600 | .17 | .22 | .34 | .49 | .82 | 1.4 | 1.6 | 2.4 | 3.5 | 4.5 | 5.5 | 7 | 8 | 10 | 19 | 31 | 44 | 57 |
| 700 | .18 | .23 | .36 | .52 | .87 | 1.4 | 1.8 | 2.6 | 3.5 | 5.0 | 6.0 | 8 | 9 | 11 | 21 | 33 | 47 | 61 |
| 800 | .18 | .24 | .38 | .54 | .92 | 1.6 | 2.0 | 2.8 | 4.0 | 5.0 | 6.0 | 8 | 10 | 12 | 22 | 36 | 50 | 65 |
| 900 | .19 | .25 | .39 | .56 | .96 | 1.6 | 2.0 | 3.0 | 4.0 | 5.5 | 7 | 9 | 10 | 12 | 24 | 38 | 53 | 69 |
| 1000 | .20 | .26 | .40 | .57 | 1.0 | 1.6 | 2.2 | 3.0 | 4.5 | 5.5 | 7 | 9 | 11 | 13 | 25 | 40 | 56 | 73 |
| 1100 | .20 | .27 | .41 | .59 | 1.0 | 1.8 | 2.2 | 3.5 | 4.5 | 6.0 | 8 | 9 | 11 | 14 | 26 | 42 | 59 | 77 |
| 1200 | .21 | .27 | .42 | .61 | 1.0 | 1.8 | 2.4 | 3.5 | 4.5 | 6.0 | 8 | 10 | 12 | 14 | 28 | 44 | 62 | 80 |
| 1300 | .21 | .28 | .43 | .62 | 1.2 | 2.0 | 2.4 | 3.5 | 5.0 | 7 | 8 | 10 | 12 | 15 | 29 | 46 | 64 | 83 |
| 1400 | .22 | .29 | .44 | .63 | 1.2 | 2.0 | 2.6 | 3.5 | 5.0 | 7 | 9 | 11 | 13 | 15 | 30 | 47 | 67 | 87 |
| 1500 | .22 | .29 | .45 | .65 | 1.2 | 2.0 | 2.6 | 4.0 | 5.5 | 7 | 9 | 11 | 13 | 16 | 31 | 49 | 69 | 90 |
| 1600 | .23 | .30 | .46 | .66 | 1.2 | 2.2 | 2.6 | 4.0 | 5.5 | 7 | 9 | 11 | 14 | 16 | 32 | 51 | 71 | 93 |
| 1700 | .23 | .30 | .47 | .67 | 1.2 | 2.2 | 2.8 | 4.0 | 5.5 | 7 | 9 | 12 | 14 | 17 | 33 | 52 | 73 | 95 |
| 2000 | .24 | .32 | .49 | .71 | 1.4 | 2.4 | 3.0 | 4.5 | 6.0 | 8 | 10 | 13 | 15 | 18 | 36 | 57 | 80 | 104 |

CONTOUR LIMITS — 2 PERCENT 400 FEET, 8 PERCENT 200 FEET, 10 PERCENT 100 FEET, 14-24 PERCENT 60 FEET. THE EFFECTIVENESS OF CONTOURING BEYOND THESE LIMITS IS SPECULATIVE.

WHEN THE LENGTH OF SLOPE EXCEEDS 400 FEET AND (OR) PERCENT OF SLOPE EXCEEDS 24 PERCENT, SOIL LOSS ESTIMATES ARE SPECULATIVE AS THESE VALUES ARE BEYOND THE RANGE OF RESEARCH DATA.

## Cropping-Management (C):

Vegetative cover, crop rotation, fertility level, tillage practices, crop residue management, and related conditions have an important effect on erosion.

The effects of cropping-management on erosion in any crop year depend somewhat on the previous crop or its residue. Most crops can be grown continuously or in combination with other crops, commonly known as crop rotation or cropping sequence. A cropping system includes the cropping sequence and the cultural and management practices used to produce a crop. Fertility level will affect the quantity of residue produced. Crop residues can be removed, left on the surface, partially incorporated into the surface soil, or plowed under. When left on the surface, the residues can be chopped or they can remain as left by the harvesting operation. Seedbeds can be left rough, increasing capacity for storage of rainfall. They can be left smooth, or they can be undisturbed as in "No-till" planting. Different combinations of these variables will have different soil losses.

The "C" factor is an indication of the erosion potential as affected by the cropping-management programs. The hazard for erosion increases as the "C" factor increases. Table 4 has been developed for a number of typical cropping systems with four combinations of tillage timing and residue management. Table 5 is for cropping systems with conservation tillage.

Individual crop years with various management conditions have been assigned "C" values as listed in Tables 6, 7, and 8. These values can be averaged for any combination of crop sequences using various combinations of tillage and residue management. These tables can also be used to evaluate alternative practices to determine which would have the most effect on reducing erosion.

### "C" FACTORS FOR CROPLAND— CONVENTIONAL TILLAGE

Table 4 can be used to determine the average annual "C" factor for any one of numerous cropping-management systems. For example, a cropping system of "corn-corn-wheat-meadow" with spring plowing and all residue left on the land would have an average annual "C" factor of .11. This table also shows the effect of crop residue management and time of tillage. For "continuous corn", for example, the "C" factor increases from .36 for spring plowing with the residue left to .53 for fall plowing and residue removed.

Table 4 also illustrates the importance of close growing crops such as wheat, oats, and meadow in controlling erosion. "Continuous corn" with spring plowing and residue left has a "C" factor of .36 while a cropping system of "corn-oats-meadow-meadow" with spring plowing and residue left has a factor of .043, only about one-tenth as much.

**TABLE 4: "C" Factors for Cropland Cropping Systems CONVENTIONAL TILLAGE**

| Cropping System | SPRING PLOW Residue Left | FALL PLOW Residue Left | SPRING PLOW Residue Removed* | FALL PLOW Residue Removed* |
|---|---|---|---|---|
| Cont. Sb | .41 | .45 | .54 | .57 |
| CSbSb | .39 | .44 | .53 | .56 |
| CSb | .38 | .43 | .52 | .55 |
| CCSb | .37 | .42 | .51 | .54 |
| Cont. C | .36 | .40 | .49 | .53 |
| CCSbOx | .27 | .31 | .33 | .38 |
| CCSbWx | .26 | .30 | .31 | .37 |
| CCCOx | .26 | .30 | .32 | .37 |
| CCCWx | .26 | .29 | .30 | .37 |
| CSbOx | .24 | .27 | .27 | .33 |
| CSbWx | .23 | .27 | .26 | .32 |
| CCOx | .22 | .26 | .26 | .32 |
| CCWx | .22 | .25 | .25 | .31 |
| COx | .20 | .24 | .25 | .30 |
| CWx | .20 | .24 | .23 | .29 |
| CCCM | .19 | .22 | .27 | .29 |
| CCSbOM | .17 | .20 | .23 | .24 |
| CCSbWM | .17 | .20 | .22 | .24 |
| CCCOM | .16 | .19 | .23 | .24 |
| CCCWM | .16 | .19 | .21 | .24 |
| CSbOM | .15 | .17 | .18 | .20 |
| CSbWM | .14 | .17 | .17 | .19 |
| CCM | .14 | .16 | .20 | .21 |
| CCCMMM | .13 | .15 | .18 | .19 |
| CSbOMM | .12 | .14 | .15 | .16 |
| CSbWMM | .11 | .14 | .14 | .16 |
| CxSbOMM | .11 | .14 | .15 | .16 |
| CxSbWMM | .11 | .14 | .13 | .16 |
| CCOM | .12 | .14 | .16 | .16 |
| CCWM | .11 | .13 | .14 | .15 |
| CxCOM | .11 | .13 | .15 | .16 |
| CxCWM | .11 | .13 | .14 | .15 |
| CCMM | .10 | .12 | .15 | .16 |
| CSbCMMM | .10 | .12 | .13 | .14 |
| CSbWMMM | .096 | .11 | .11 | .13 |
| CCOMM | .093 | .112 | .12 | .13 |
| CCWMM | .093 | .108 | .12 | .12 |
| CxCOMM | .093 | .111 | .13 | .13 |
| CxCWMM | .092 | .108 | .12 | .12 |
| CCOMMM | .078 | .094 | .11 | .11 |
| CCWMMM | .078 | .091 | .10 | .10 |
| CxCOMMM | .078 | .094 | .107 | .11 |
| CxCWMMM | .078 | .091 | .096 | .10 |
| CM | .071 | .080 | .09 | .10 |
| COWMM | .056 | .060 | .066 | .068 |
| COM | .055 | .072 | .066 | .077 |
| CWM | .055 | .065 | .061 | .070 |
| COMM | .043 | .055 | .051 | .059 |
| CWMM | .042 | .051 | .047 | .054 |
| CWMMM | .035 | .041 | .038 | .044 |
| CWMMMM | .029 | .035 | .033 | .038 |

**DOUBLE CROPPING****

| | |
|---|---|
| WSb (Conventional)*** | .20 |
| WSb (No-Till) | .11 |
| MC (No-Till) | .070 |

C=Corn Sb=Soybeans M=Meadow
O=Spring grain x=Cover or green manure crop
* Residue removed includes corn stover

**Double cropping — Growing two crops on the same field in a single year. ***Conventional tillage for WSb Double Cropping includes discing for wheat seedbed and plowing for soybeans following wheat harvest.

### TABLE 5: "C" Factors for Cropland Cropping Systems CONSERVATION TILLAGE

PREVIOUS CROP RESIDUE ON SOIL SURFACE* (CORN EQUIVALENT — LBS.)

| Residue** Incorporated Below Soil Surface —Lbs. / Cropping System | 1000-1500 | | | | 1500-2000 | | | 2000-3000 | | | 3000-4000 | | | 4000-6000 | | 6000+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0-1000 | 1000-3000 | 3000-5000 | 5000+ | 0-1000 | 1000-3000 | 3000+ | 0-1000 | 1000-3000 | 3000+ | 0-1000 | 1000-2000 | 2000+ | 0-1000 | 1000+ | 0-1000 |
| Con.R. Spr.Till | .33 | .31 | .27 | .24 | .25 | .24 | .21 | .19 | .18 | .16 | .14 | .13 | .12 | .075 | .074 | .030 |
| Con.R. Fall Till | .34 | .32 | .28 | .25 | .26 | .25 | .22 | .20 | .19 | .17 | .15 | .14 | .13 | .081 | .080 | — |
| RRRSgx | .21 | .20 | .18 | .17 | .18 | .17 | .15 | .15 | .14 | .13 | .12 | .11 | .11 | .087 | .086 | .038 |
| RRSgx | .18 | .17 | .16 | .15 | .15 | .14 | .13 | .13 | .13 | .12 | .11 | .11 | .10 | .091 | .090 | .040 |
| RRRSgM | .17 | .16 | .15 | .14 | .14 | .13 | .12 | .12 | .11 | .10 | .097 | .094 | .090 | .071 | .070 | .031 |
| RRSgM | .13 | .13 | .12 | .11 | .12 | .11 | .10 | .10 | .097 | .092 | .086 | .084 | .082 | .070 | .069 | .032 |
| RRSgMM | .11 | .10 | .095 | .089 | .093 | .090 | .083 | .081 | .078 | .075 | .070 | .068 | .066 | .057 | .056 | .026 |
| RSgMM | .052 | .046 | .042 | — | .050 | .044 | .040 | .048 | .042 | .038 | .044 | .038 | .036 | .037 | .036 | .023 |

*The average annual amount of previous crop residue in pounds per acre remaining on the soil surface after planting of the row crops in the cropping system.

**The average annual amount of previous crop residue in pounds per acre incorporated into the soil by the tillage and planting operations for the row crops in the cropping system.
CORN EQUIVALENT — Small grain, soybean, and meadow residues (by weight) are twice as effective as corn residue; therefore, the quantity should be doubled to convert to "Corn Equivalent."
The amounts of previous crop residue should be determined by sample measurement or by comparing the field situation with photographs of measured amounts of residue before tillage and after planting (See Section on DETERMINING AMOUNTS OF RESIDUE). The amounts of residue can also be estimated using Table 9.

***R=row crop, Sg=small grain, M=Meadow, x=cover or green manure crop

Tables 6 and 7 list individual crop year values for row crops, small grain and meadow with conventional tillage and a high level of soil fertility. Time of tillage is included in Table 6 for row crops; and the previous crop effect and residue management are included in both Tables. These Tables can be used to determine the average annual "C" factor for almost any kind of cropping sequence, even one which has various combinations of tillage timing and residue management within the system. The individual values from the Tables are simply averaged to get a value for a cropping system.

Example 1: A rotation of "corn-corn-wheat-meadow" is followed using conventional tillage. The first year of corn is planted in meadow residue following spring plowing. After grain harvest the corn stover is left

### TABLE 6: "C" Factors for Row Crops "One Crop Year"* CONVENTIONAL TILLAGE

| | Residue Left | | | | | | | | Residue Removed | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Previous Crop | Spring Plow | | | | Fall Plow | | | | Spring Plow | | | | Fall Plow | | | |
| Crop | C | Sb | Sg | M | C | Sb | Sg | M | C | Sb | Sg | M | C | Sb | Sg | M |
| Corn | .27 | .36 | .27 | .14 | .31 | .40 | .31 | .16 | .43 | .49 | .40 | .18 | .44 | .51 | .44 | .20 |
| Corn-x | .26 | .34 | .27 | .13 | — | — | — | — | .42 | .47 | .29 | .17 | — | — | — | — |
| Corn-x (3+ yrs.) | .36 | .36 | .36 | .36 | .40 | .40 | .40 | .40 | .49 | .49 | .49 | .49 | .53 | .53 | .53 | .53 |
| Corn-x (3+ yrs.) | .30 | .30 | .30 | .30 | — | — | — | — | .43 | .43 | .43 | .43 | — | — | — | — |
| Soybeans** | .38 | .41 | .38 | .37 | .42 | .45 | .42 | .41 | .51 | .54 | .51 | .50 | .55 | .59 | .55 | .52 |
| Soybeans-x | .36 | .39 | .36 | .36 | — | — | — | — | .49 | .52 | .49 | .48 | — | — | — | — |

*Factors estimate longtime-average soil loss. Actual soil loss during one year may differ widely from average values.
**Soybeans 3 or more years, use same factor as soybeans following soybeans.

on the field and plowed down in the fall and planted to corn the following spring. The second year corn is harvested for silage so the residue is removed. The field is planted to wheat followed by residue removal and summer seeding to meadow. The individual values are corn, .14 since the corn follows meadow with residue plowed down; second year corn, .31 since the corn followed corn, fall plowed with the residue left; wheat, .08 since the previous crop residue was removed and the wheat was followed by summer seeding to meadow; and meadow, .009. This provides an average annual "C" factor of .13 as determined by (.14 + .31 + .08 + .009) ÷ 4 yrs. in the rotation.

The comparative soil conservation effects of small grains and meadow can be seen in Table 7.

**TABLE 7: "C" Factors For Small Grain and Meadow "One Crop Year"* CONVENTIONAL TILLAGE**

| Previous Crop / Crop | Residue Left C | Residue Left Sb | Residue Left Sg | Residue Left M | Residue Removed C | Residue Removed Sb | Residue Removed Sg | Residue Removed M |
|---|---|---|---|---|---|---|---|---|
| Wheat** | .07 | .07 | — | — | .09 | .09 | — | — |
| Wheatx | .06 | .06 | — | — | .08 | .08 | — | — |
| Wheat-M(ss) | .06 | .06 | — | — | .08 | .08 | — | — |
| Wheat-Sb | .20 | .20 | — | — | .22 | .22 | — | — |
| Wheat-Sb (no-till) | .11 | .11 | — | — | .13 | .13 | — | — |
| Oats | .05 | .05 | — | — | .07 | .07 | — | — |
| Oats-x | .04 | .04 | — | — | .06 | .06 | — | — |
| Oats-M(ss) | .04 | .04 | — | — | .06 | .06 | — | — |
| Meadow | .005 | .005 | .005 | .005 | .009 | .009 | .009 | .009 |
| Meadow (3+ yrs.) | — | — | .005 | — | — | — | .009 | — |

* Factors estimate long-time average soil loss. Actual soil loss during one year may differ widely from average values.

C = Corn
Sb = Soybeans
Sg = Small Grain
M = Meadow
x = Cover or Green Manure Crop
(ss) = Summer Seeding
** = Use same factors for other winter grain

**TABLE 8: "C" Factors for Cropland — "One Crop Year"* CONSERVATION TILLAGE**

**PREVIOUS CROP RESIDUE ON SOIL SURFACE** (CORN EQUIVALENT—LBS.)**

| Residue*** Incorporated Below Soil Surface -Lbs. / Crop | 0-1000: 0-1000 | 0-1000: 1000-3000 | 0-1000: 3000-5000 | 0-1000: 5000+ | 1000-2000: 0-1000 | 1000-2000: 1000-3000 | 1000-2000: 3000+ | 2000-3000: 0-1000 | 2000-3000: 1000-3000 | 2000-3000: 3000+ | 3000-4000: 0-1000 | 3000-4000: 1000-2000 | 3000-4000: 2000+ | 4000-6000: 0-1000 | 4000-6000: 1000+ | 6000+: 0-1000 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Row Crop | .53 | .43 | .38 | .36 | .30 | .28 | .25 | .20 | .18 | .16 | .14 | .13 | .12 | .08 | .07 | .03 |
| Row Crop-x | .43 | .35 | .32 | .30 | .20 | .18 | .16 | .13 | .13 | .11 | .10 | .10 | .09 | .07 | .07 | .04 |
| Small Grain | .10 | .07 | .06 | .06 | .07 | .07 | .06 | .07 | .07 | .06 | .07 | .06 | .06 | .06 | .06 | .04 |
| Small Grain-x | .09 | .06 | .05 | .05 | .06 | .06 | .05 | .06 | .06 | .05 | .06 | .05 | .05 | .05 | .05 | .03 |

*Factors estimate longtime-average soil loss. Actual soil loss during one year may differ widely from average values.
**The amount of previous crop residue in pounds per acre remaining on the soil surface after planting.
***The amount of previous crop residue incorporated into the soil by the tillage and planting operations.
CORN EQUIVALENT—Small grain, soybean and meadow residues (by weight) are twice as effective as corn residue; therefore, the quantity should be doubled to convert to "Corn Equivalent."
The amounts of previous crop residue should be determined by sample measurement or by comparing the field situation with photographs of measured amounts of residue before tillage and after planting (See Section on DETERMINING AMOUNTS OF RESIDUE). The amounts of residue can also be estimated using Table 9.

Wheat has a value of .07 and meadow .005 where residues are left. If soybeans are double cropped after wheat with conventional tillage and residue removed, the value is .22. Planting the soybeans in the wheat where the straw is removed using no-till planting reduces the value to .13.

## "C" FACTORS FOR CROPLAND— CONSERVATION TILLAGE

When using conservation tillage, management of the crop residue is the key element in determining the erosion potential of the cropland. The total quantity of residue remaining after crop harvest, the amount incorporated into the soil by tillage, and the amount remaining on the soil surface at planting time are all important to potential soil erosion. The difference between the effects of corn and soybeans, for example, is reflected in Tables 5 and 8 by the different amounts of residue produced by the crop and left after crop harvest. A continuous row crop leaving 5000 lbs. of residue on the surface and less than 1000 lbs. incorporated with spring tillage has a value of .075 from Table 5. Another rowcrop leaving only 1800 lbs. of residue on the surface and less than 1000 lbs. incorporated has a value of .25, thereby having more than three times as much potential soil loss.

The kind of residue is also important in erosion control. Sod residues and small grain and bean straws give greater protection to the soil surface than the coarser residues such as corn stover when compared on a weight basis. Tables 5 and 8 are based on "corn equivalent" residue, so the increased value of the finer textured residues is accounted for by doubling the weight.

The previous crop residue amounts must be averaged for the row crop years in a cropping system to get the residue amounts to use with Table 5. For example, a cropping system consisting of "row crop-row crop-small grain-meadow" having 2500 lbs. of meadow residue providing cover for the first year row crop and 6500 lbs. of row crop residue as cover for the second year row crop would have an average value of 5750 lbs. for use in determining the "C" value for the cropping system from Table 5. The higher quality meadow residue value is doubled $[(2x2500) + 6500] \div 2 = 5750$.

Table 8 gives the "C" value with conservation tillage for individual crop years. This allows the flexibility for determining the "C" value for any sequence of crops in a cropping system. Table 8 can also be used in combination with Tables 6 and 7 for determining the "C" value when some of the crops in a cropping system are planted with conservation tillage and some with conventional tillage.

## DETERMINING AMOUNTS OF RESIDUE

The quantity of crop residues can be estimated by 1) measuring sample areas, 2) visually comparing to a photograph of a measured quantity, or 3) using crop yields as a base.

To estimate from sample areas, first collect crop residues from three one-square yard plots selected at random. (A one-square yard wire frame makes plot marking easier). Collect all residue down to the soil surface and shake out soil and stones. Air dry if necessary and weigh all three samples. Record the total combined weight in *ounces* and multiply by 100. The answer will be a good approximation of the quantity of residue in *pounds per acre*.

Quantities of residue on the soil surface can also be estimated by visually comparing what is seen on your fields with photographs in Figure 2 of this bulletin, in U.S.D.A. Leaflet 554 (Mulch Tillage in Modern Farming), or in Ohio SCS Booklet — Modern Farming with Conservation Tillage.

To estimate amounts of residue from crop yields, use Table 9. For example, a corn crop will produce approximately 60 pounds of residue for every bushel of grain. A 120 bushel corn crop will, therefore, produce approximately (120 x 60) 7200 pounds of residue. About 25 percent of the previous crop will be lost or decomposed over winter, so the quantity determined by crop yield based estimation or harvest time measurement should be reduced by 25 percent to determine spring planting time amount. Table 9 lists the percent of surface residue incorporated by various conservation tillage or planting techniques. These can be used individually or in succession to reflect various combinations of practices.

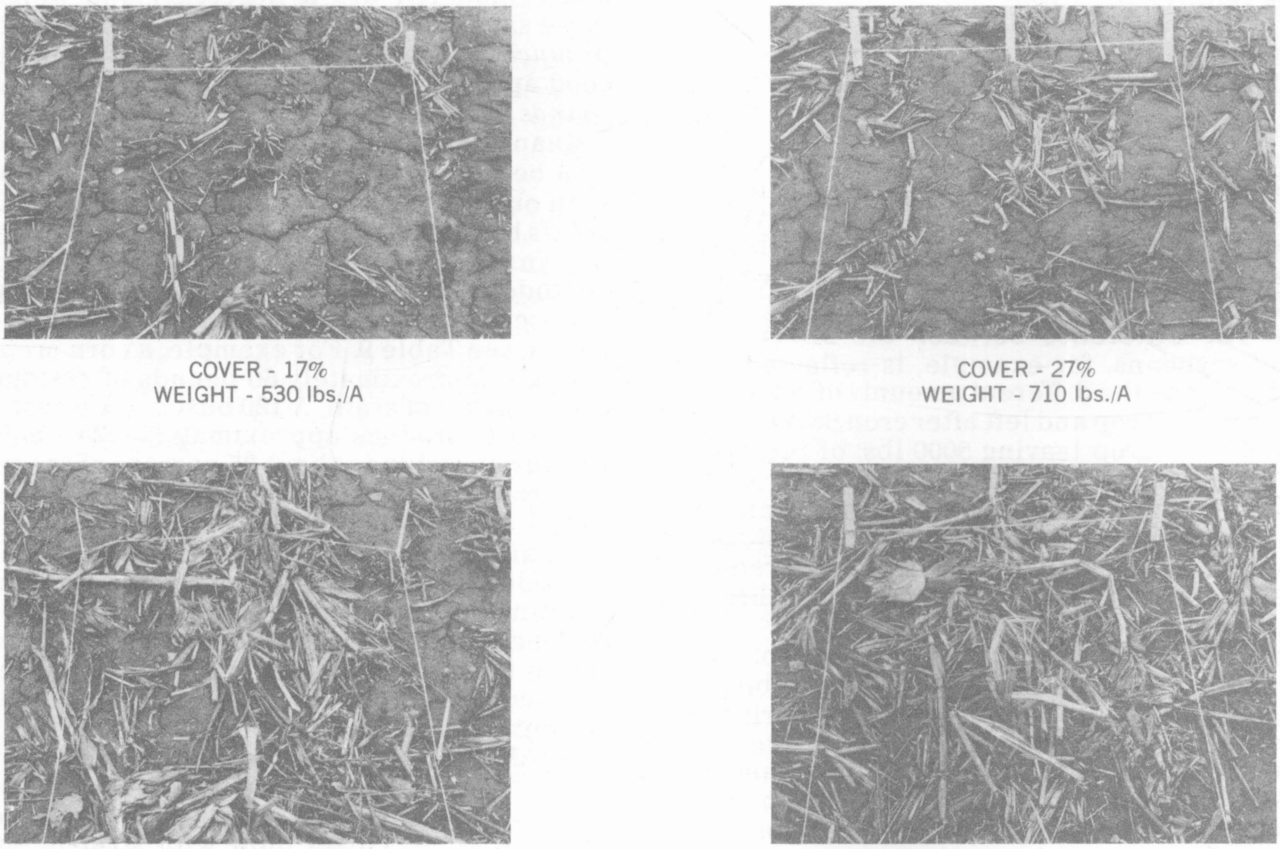
**EXAMPLE 2:** A cropping system of continuous corn producing an average of 120 bu. of grain is being used. A chisel plow with straight shovel points is used following harvest in the fall and the succeeding crop is planted with a no-till planter. Determine the residue incorporated and remaining residue on the surface after planting.

**TABLE 9: Estimating Quantities of Residue**

| CROP | Residue produced (lbs.) per bu. of grain |
|---|---|
| Corn | 60 |
| Soybeans | 50 |
| Small Grain | 100 |
| Meadow | Estimate as for a hay crop |

| CONDITION OR TYPE OF EQUIPMENT | ESTIMATED RESIDUE LOST OR INCORPORATED WITH EACH OPERATION (Percent) |
|---|---|
| 1) Decomposition loss over winter | 20-30 |
| 2) Chisel Plow (shanks spaced 12-15 in.) | |
| a. straight shovel points | 20-40 |
| b. twisted shovel points | 40-60 |
| 3) Disc (tandem or offset) | |
| a. less than 23 in. diameter blades | 20-40 |
| b. 23-28 in. diameter blades | 40-60 |
| c. more than 28 in. diameter blades | 60-80 |
| 4) No-till planter (fluted coulter) | 0-5 |
| 5) Strip or till planter | 10-15 |

**FIGURE 2: Corn Residue Cover on Soil Surface**



COVER - 17%
WEIGHT - 530 lbs./A

COVER - 27%
WEIGHT - 710 lbs./A

COVER - 60%
WEIGHT - 3280 lbs./A

COVER - 73%
WEIGHT - 3820 lbs./A

(Schmidt and Bernath, 1966)

Using Table 9, the estimated quantity of residue produced is 7200 lbs. (120 bu. x 60 lbs. residue per bu. grain). The chisel plow incorporates 30 percent (7200 x 30% = 2160) leaving 5040 lbs. on the surface (7200-2160). Over winter loss of 25 percent reduces the amounts to 1620 lbs. incorporporated (2160-25%) and 3780 lbs. on the surface (5040-25%). These quantities can be used in conjunction with Table 5 to get an average annual "C" value of .14 for continuous row crop with fall tillage.

## DETERMINING THE "C" FACTOR

Tables 6, 7, and 8 can be used in combination with each other. This provides nearly unlimited flexibility for determining the average annual "C" factor for a crop rotation of any length and any combination of tillage practices. These "C" factors have been developed for individual crop years and can be averaged to get the "C" factor for any cropping system. The factors may vary slightly however, from the factors for rotations in Tables 4 and 5 due to the interacting effects of previous crops and rounding of numbers in developing the Tables.

**EXAMPLE 3:** A dairy farmer uses the following typical seven year rotation:

C-C(x)-C-W(Mss)-M-M-M

He spring plows the third year meadow which had residue left and he plants the first year corn using conventional tillage. FROM TABLE 6: FIRST YEAR CORN "C" FACTOR IS .14.

He uses a no-till planter to plant the second and third year corn crops without tillage. His corn crops average about 100 bushels per acre. Estimate about 6,000 pounds of residue from the previous corn crop, reduced by 25% over winter leaves about 4500 pounds of residue on the surface after planting and no residue incorporated. The corn is harvested for silage and the field is seeded to rye for winter cover. FROM TABLE 8: SECOND YEAR ROW CROP (x) "C" FACTOR IS .07.

The rye is killed with herbicides leaving a residue of about 2500 pounds, estimated as compared to a hay crop and the corn is again harvested for silage. The field is then seeded to wheat. Row crop (x) is again used from Table 8 since it was seeded to wheat following harvest. The previous crop residue was 2500 pounds (5000 lbs. corn equivalent) with none incorporated. FROM TABLE 8: THIRD YEAR ROW CROP (x) "C" FACTOR IS .07.

The wheat is summer seeded to meadow following harvest and straw removal. USING TABLE 7: THE WHEAT-M(ss) "C" FACTOR IS .08.

The three meadow years in the rotation are harvested for hay. USING TABLE 7: FIRST, SECOND, AND THIRD YEAR MEADOW "C" FACTOR IS .009.

The factors are averaged as follows:

C-C(x)-C-W(Mss)-M-M-M

.18+.07+.07+.08+.009+.009+.009 =.427

The average "C" factor for the rotation cycle is .061 determined by (.427−7 yrs. in the rotation).

**EXAMPLE 4:** A beef cattle farmer is using a five year rotation of:

C-C-C-W-M

He fall plows after the first and second years of corn, uses conventional tillage, removes the second and third year corn residue for silage, and removes the wheat straw for bedding. He averages about 110 bu. of corn per acre and about 45 bu. of wheat per acre. He had several years of severe soil erosion so he visited the Soil and Water Conservation District office about his erosion problem. The staff found from the soil maps that he had Blount and Morley soils and that the tolerable soil loss, if he wanted to maintain productivity, was three tons per acre per year. Using the soil loss equation, they found that he was averaging about six tons per acre per year soil loss. He decided to evaluate his cropping management program and look at other alternatives. Using Tables 6 and 7 he found the following "C" factors for his cropping system:

C-C-C-W-M;

.14+.31+.53+.08+.009=1.07

or an average annual "C" of slightly over .21 determined by (1.07−5).

ALTERNATIVE 1. Eliminate the third year of corn and add another year of meadow which would be used for silage. Everything else would remain the same. C-C-W-M-M;

.14+.31+.08+.009+.009=.55

or an average annual "C" of .11, about half, which would reduce soil loss by half.

ALTERNATIVE 2: Three years of corn with second and third years harvested for silage. A rye crop would be seeded after the second year corn because the residue was removed and therefore, the erosion potential was high. It produced an estimated 2500 lbs. of residue (5000 lbs. corn equivalent). Wheat would be seeded after third year corn. The second and third years of corn would be planted with a no-till planter without other tillage.

C-C-C-W-M;

.14+.07+.07+.08+.009=.37

or an average "C" of just over .07 which would reduce soil loss to well under three tons per acre.

ALTERNATIVE 3: The first year of corn would be planted following spring plowing and conventional tillage, "C" = .14 from Table 6. The field would be disced (25 in. diam. blades) following harvest and planted to the second year corn with a no-till planter. Discing of about 6600 lbs. of corn residue incorporated half of it and over winter decomposed another 25%, leaving 2475 lbs. incorporated and 2475 lbs. on the surface. The corn was harvested for silage and seeded to rye, "C"=.13 from Table 8. The rye developed an estimated 2500 lbs. (5000 lbs. corn equivalent) of residue by planting time. It was killed with herbicides, disced once with the same disc, and planted with the no-till planter to the 3rd year of corn which was again harvested for silage and then seeded to wheat, "C"=.13 from Table 8. From Table 7, wheat with residue removed and summer seeded to meadow would have a "C"=.08. The "C" for meadow with residue removed is .009. Summarizing this alternative provides .10 average annual "C" for the rotation.

All three alternatives would meet the objectives of reducing soil loss by half. Alternative 1 would change the crops produced shifting his feeding program to half corn silage and half hay silage. Alternatives 2 and 3 would essentially maintain the same crop production but would require a knowledge of the techniques of conservation tillage.

**TABLE 10: "C" Factors for Permanent Pasture, Rangeland, and Idle Land[1]**

| Vegetal Canopy | | Cover That Contacts the Surface | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Type and Height of Raised Canopy[2] | Canopy Cover[3] | Type[4] | Percent Ground Cover | | | | | |
| | | | 0 | 20 | 40 | 60 | 80 | 95-100 |
| Column. No.: | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| No appreciable canopy | | G | .45 | .20 | .10 | .042 | .013 | .003 |
| | | W | .45 | .24 | .15 | .090 | .043 | .011 |
| Canopy of tall weeds or short brush (0.5 m fall ht.)[2] | 25 | G | .36 | .17 | .09 | .038 | .012 | .003 |
| | | W | .36 | .20 | .13 | .082 | .041 | .011 |
| | 50 | G | .26 | .13 | .07 | .035 | .012 | .003 |
| | | W | .26 | .16 | .11 | .075 | .039 | .011 |
| | 75 | G | .17 | .10 | .06 | .031 | .011 | .003 |
| | | W | .17 | .12 | .09 | .067 | .038 | .011 |
| Appreciable brush or bushes (2 m fall ht.)[2] | 25 | G | .40 | .18 | .09 | .040 | .013 | .003 |
| | | W | .40 | .22 | .14 | .085 | .042 | .011 |
| | 50 | G | .34 | .16 | .085 | .038 | .012 | .003 |
| | | W | .34 | .19 | .13 | .081 | .041 | .011 |
| | 75 | G | .28 | .14 | .08 | .036 | .012 | .003 |
| | | W | .28 | .17 | .12 | .077 | .041 | .011 |
| Trees but no appreciable low brush (4 m fall ht.)[2] | 25 | G | .42 | .19 | .10 | .041 | .013 | .003 |
| | | W | .42 | .23 | .14 | .087 | .042 | .011 |
| | 50 | G | .39 | .18 | .09 | .040 | .013 | .003 |
| | | W | .39 | .21 | .14 | .085 | .042 | .011 |
| | 75 | G | .36 | .17 | .09 | .039 | .012 | .003 |
| | | W | .36 | .20 | .13 | .083 | .041 | .011 |

[1] All values shown assume: (1) random distribution of mulch or vegetation, and (2) mulch of appreciable depth where it exists.
[2] Average fall height of waterdrops from canopy to soil surface: m=meters.
[3] Portion of total-area surface that would be hidden from view by canopy in a vertical projection, (bird's-eye view).
[4] G: Cover at surface is grass, grasslike plants, decaying compacted duff, or litter at least 2 inches deep.
W: Cover at surface is mostly broadleaf herbaceous plants (as weeds) with little lateral-root network near the surface, and/or undecayed residue.

### Pasture, Range and Idle Land "C" Factor

Table 10, **"C" Factors for Permanent Pasture, Rangeland and Idle Land,** shows cropping-management factors for these types of lands. As in cropland, there are several variables which cannot be evaluated independently because of the many interactions. These variables include type and height of raised canopy, percent of canopy cover, and type and percent of ground cover.

a. A tall fescue pasture with an excellent stand of grass would have no appreciable raised canopy, cover that contacts the surface is grass or "G", and percent ground cover is 95-100. The "C" factor is 0.003.
b. A bluegrass pasture with a poor stand of grass would have a raised canopy of tall weeds, a 25 percent canopy cover, cover that contacts the surface is grass or "G", percent ground cover is 60. The "C" factor is 0.038.

This table points out the importance of the amount of cover and the type of cover in pastureland. As the percent of ground cover increases, the hazard of erosion decreases. In Example a, the "C" factor is 0.45 with 0 percent ground cover, while the "C" factor is 0.003 with 95-100 percent ground cover.

In the same example, the type of cover illustrates that grass type cover "G" gives more erosion protection than does broadleaf herbaceous plants "W." With 20 percent ground cover the "C" factor for "G" is .20 while the "C" factor for "W" is .24.

### Woodland "C" Factor

Table 11 shows **"C" Factors for Woodland.** The variables involved include stand condition, percent tree canopy, and forest litter — percent of area, and undergrowth.

Woodland of oaks and maples, well stocked, tree canopy 90% of area, forest litter 90% of area, undergrowth managed, the "C" factor is .001.

Most sediment from woodland originates from logging roads and skid trails. The "Woodlands of the Northeast, Erosion and Sediment Control Guides" (1977) provides treatment alternatives but no minimum standards are given.

### Critical Areas

Areas of exposed subsoil, steep slopes or with no vegetation, require special treatment to control erosion. Such sites are called critical areas because they erode severely and are the source of much sediment if they are not stabilized. If the right combination of conservation practices is

**TABLE 11: "C" Factors for Woodland**

| Stand Condition | Tree Canopy % of Area[1] | Forest Litter % of Area[2] | Undergrowth[3] | "C" Factor |
|---|---|---|---|---|
| Well Stocked | 100-75 | 100-90 | Managed[4] | .001 |
| | | | Unmanaged[4] | .003-.011 |
| Medium Stocked | 70-40 | 85-75 | Managed | .002-.004 |
| | | | Unmanaged | .01-.04 |
| Poorly Stocked | 35-20 | 70-40 [5] | Managed | .003-.009 |
| | | | Unmanaged | .02-.09[5] |

[1] When tree canopy is less than 20%, the area will be considered as grassland, or cropland for estimating soil loss.
[2] Forest litter is assumed to be at least two inches deep over the percent ground surface area covered.
[3] Undergrowth is defined as shrubs, weeds, grasses, vines, etc., on the surface area not protected by forest litter. Usually found under canopy openings.
[4] Managed—grazing and fires are controlled.
Unmanaged—stands that are overgrazed or subjected to repeated burning.
[5] For unmanaged woodland with litter cover of less than 75%, C values should be derived by taking 0.7 of the appropriate values in Table 10. The factor of 0.7 adjusts for the much higher soil organic matter on permanent woodland.

used, soil losses by erosion can be held to a level that can be tolerated. Frequently, an annual crop or mulch cover will provide the protection needed.

Table 12, **"C" Factors for Annual Cover and Various Quantities of Mulch**, shows the "C" factor for bare areas is 1.0, for one ton of straw mulch, 0.18, and for annual vegetative cover, 0.15.

**TABLE 12: "C" Factors for Annual Cover, and Various Quantities of Mulch**

| Cover or Mulch | "C" Factor |
|---|---|
| bare areas | 1.0 |
| ¼ ton straw mulch | .52 |
| ½ ton straw mulch | .35 |
| ¾ ton straw mulch | .24 |
| 1 ton straw mulch | .18 |
| 1½ ton straw mulch | .10 |
| 2 ton straw mulch | .06 |
| 3 ton straw mulch | .03 |
| 4 ton straw mulch | .02 |
| annual cover crop | .15 |

## Erosion Control Practices (P):

Soil erosion control practices such as contour tillage, contour stripcropping, terraces, and diversions with stabilized waterways may be used in addition to tillage and cropping systems. Contouring and stripcropping have been assigned P values based on their relative effectiveness. These values are shown in Table 13.

**Contouring** is the practice of planting all row crops and performing tillage across the slope or on the contour. It is most effective on slopes in the

**TABLE 13: "P" Factors for Erosion Control Practices**

| % Slope | Up-Down Hill | Contouring | Contour Strip Cropping Alternate Strip In: Meadow | Small Grain |
|---|---|---|---|---|
| 2-7 | 1.0 | 0.5 | 0.25 | 0.33 |
| 7-12 | 1.0 | 0.6 | 0.30 | 0.40 |
| 12-18 | 1.0 | 0.8 | 0.40 | 0.53 |
| 18-24 | 1.0 | 0.9 | 0.45 | 0.60 |

2 to 7 percent range where it reduces erosion 50 percent compared to up-and-down hill farming. On flatter slopes the row acts like a terrace, while on steeper slopes the water holding capacity of the row decreases and becomes ineffective. To get the full benefit of contouring, fields should be relatively free of gullies, and waterways should be grassed. The slope-length limits for contouring based on judgement values are 400 feet on 2 percent slope, 300 feet on 4 to 6 percent slope, 200 feet on 8 percent slope, and 100 feet on 10 percent slope.

**Contour stripcropping** is the practice of alternating strips of meadow and row crops or small grain and row crops all planted on the contour. This is a more effective erosion control practice than contouring alone. Strip widths range from 60 feet on steep slopes (12 to 18%), up to 100 feet on 2 percent slopes. The actual width can be adjusted to fit machinery sizes.

**Terracing** consists of a series of across-slope channels, with tillage and planting parallel to these channels. Diversions are similar to terraces, but are usually seeded to grass vegetation. Both are designed to divert water to a stable outlet. Terraces control soil erosion by reducing slope length exposed to runoff, and are more effective for erosion control than stripcropping. The terrace spacing becomes the slope length for estimating expected soil loss.

Contour stripcropping

## EXAMPLES OF THE USES OF THE SOIL LOSS EQUATION

In order to use the soil loss prediction equation, one must determine the field location, soil series, percent slope, length of slope, cropping-management and erosion control practices:

1. Rainfall (R), the R values can be read from Figure 1 by locating the county and taking the nearest R value or by interpolation.
2. Soil Erodibility (K), Table 2 gives K values. In order to determine soil erodibility, the soil series must be known. One of the more helpful tools available to get a description of the soil series is a soil survey report. Status of soil surveys is shown in Figure 3. If, however,

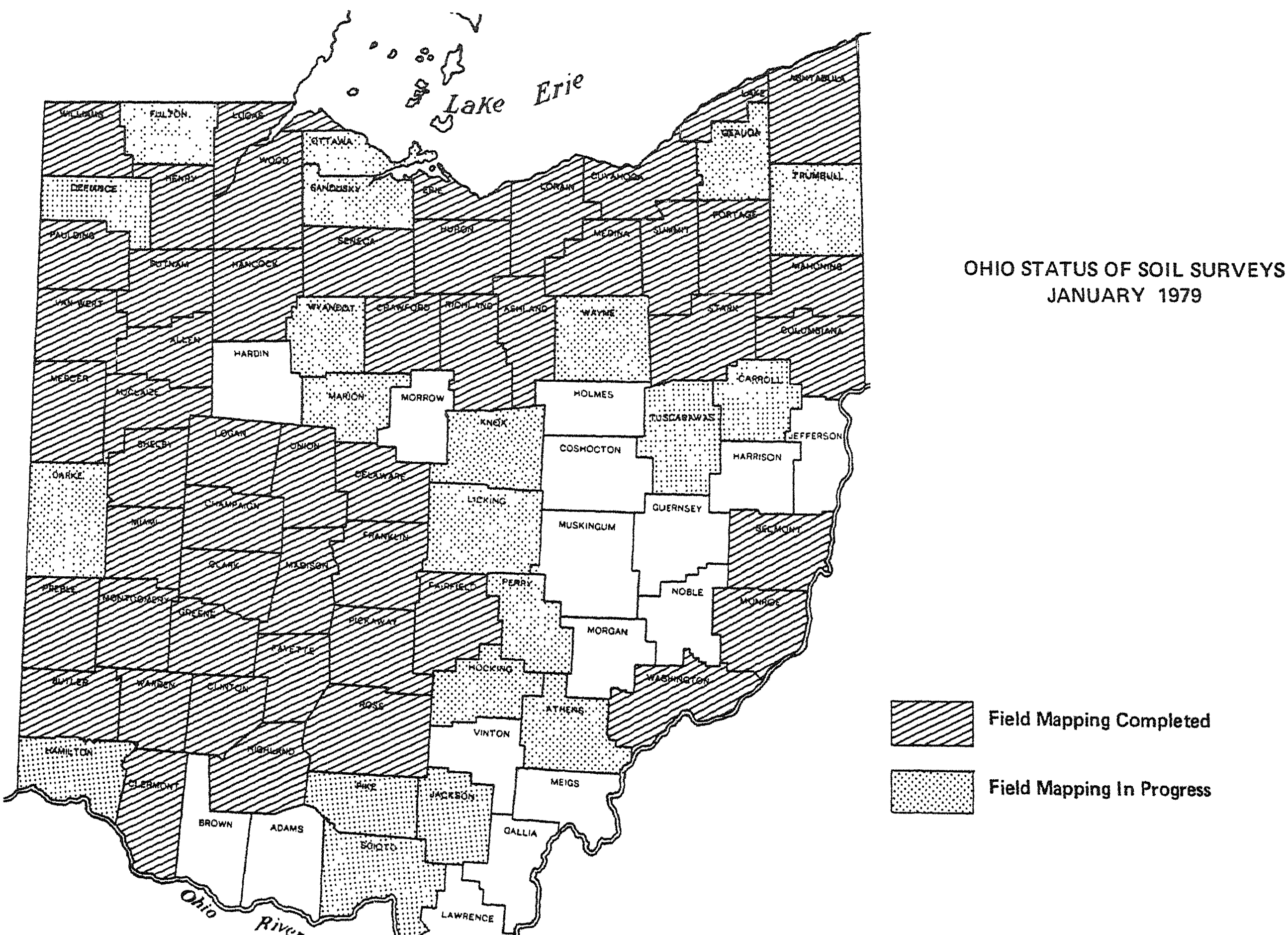



**FIGURE 3: Ohio Status of Soil Surveys, January, 1979**

a soil survey is not available, contact the local soil and water conservation district.

3. Slope Length and Steepness (LS), The effects of slope length and steepness have been combined into LS value as shown in Table 3.

   Slope is measured from where flow begins to point of deposition. A point of deposition can be (1) where runoff enters a well defined channel which may be part of a drainage network, (2) a constructed channel such as a terrace or diversion, (3) sink or kettle hole, (4) stream bottom, or (5) other continous obstruction to a slope. The length and steepness of slope is determined between these two points. (Figure 4.) This measured interval becomes the slope length for estimating expected soil loss.

   Slope steepness is also measured from where flow begins to a point of deposition. The interval between points used for measuring slope length are the same used in measuring slope steepness. Slope is normally measured with a hand level or similar device and is expressed in terms of percentage. It is important in determining slope that the height of eye level and the point of aim, either up or down slope, are the same height.

   The soil survey is a source of slope information. Ranges in slope steepness are described for each mapping unit. With accurate mapping and classification of intermittent drainage, a skillful reader of a soil map can visualize length and direction of soil slope from a detailed soil map.

4. Cropping-Management (C), Tables 4 through 12 give C values. It is necessary to know the cropping sequence, crop residue management, crop yield, and tillage methods to select proper values from the tables.

5. Erosion Control Practice (P), Table 13 gives P values. It is necessary to know the erosion control practices applied, such as contouring, contour stripping, and terraces.

Soil losses can be estimated by taking the product of the five factors: rainfall (R), soil erodibility (K), slope length and steepness (LS), cropping-


**FIGURE 4: Slope Measurement**

management (C), and erosion control practice (P). For example, if the rainfall is 150, soil erodibility is 0.3, LS (10% and 200 feet) slope length and steepness is 2.0, and the crop management factor is 0.15, the average annual soil loss for up-and-downhill farming is (150 x 0.3 x 2.0 x 0.2) 13.5 tons/acre, This loss can be reduced by erosion control practices, such as contouring, as shown in Table 9.

In the above example where the land slope was 10%, contour stripcropping would reduce the soil loss to (13.5 x 0.30), or 4.05 tons/acre, an acceptable level for many soils.

## SOIL LOSS TOLERANCE FACTORS (T)

Soil Loss Tolerance Factors (T), Table 2, sometimes called permissible soil loss values, are the maximum rate of soil erosion that will allow a high level of crop production to be sustained economically and indefinitely (Wischmeier and Smith, 1978). These factors are expressed in terms of average soil loss per acre per year. Establishment of the T values were based on research data, experience, and knowledge of the characteristics for each soil series. This includes such criteria as soil properties, soil depth, rooting depth, permeability, and prior erosion. In Ohio, maximum soil loss tolerance values range from 1 to 5 tons per acre per year, depending on the above criteria. A single T value is normally assigned to each soil series. A second, lower T value may be assigned to certain soils where erosion has significantly reduced the thickness of the root zone. More detailed descriptions of the Soil Loss Tolerance Factor (T) and values for Ohio soils are given in Table 2.

In using the Soil Loss Tolerance Factor, predictions of the expected rate of soil erosion from a given set of cropping and management systems on a particular field are first obtained by use of thė Universal Soil Loss Equation and/or the Wind Erosion Equation. These losses are compared to the T values or permissable soil loss established for that soil. If the predicted loss exceeds the permissible loss, alternative sets of practices or management plans must be selected that will meet the T value for that soil.

### Nearly Level Land
### (Less Than 2 Percent Slope)

About 40 percent of the state's agricultural land has little or no slope (less than 2 percent). A large percentage of this area is in northwestern and western Ohio. These soils have minor erosion problems and little concern has been given to soil loss. Soil loss occurs on these soils, because of their high content of fine clay that is easily dispersed and carried by surface runoff. This area is characterized by a high percentage of intensive cropping and bare soil surfaces over winter and early spring. Research is now underway to define actual losses on these nearly level soils, and to develop control practices.

While the soil loss tolerances for agricultural productivity can be met on these soils, it may be difficult to achieve the water quality goals being suggested in some reports. Annual sediment yield of streams with drainage areas greater than 50 square miles is given in Figure 5. One hundred tons per square mile equals 312 pounds per acre.

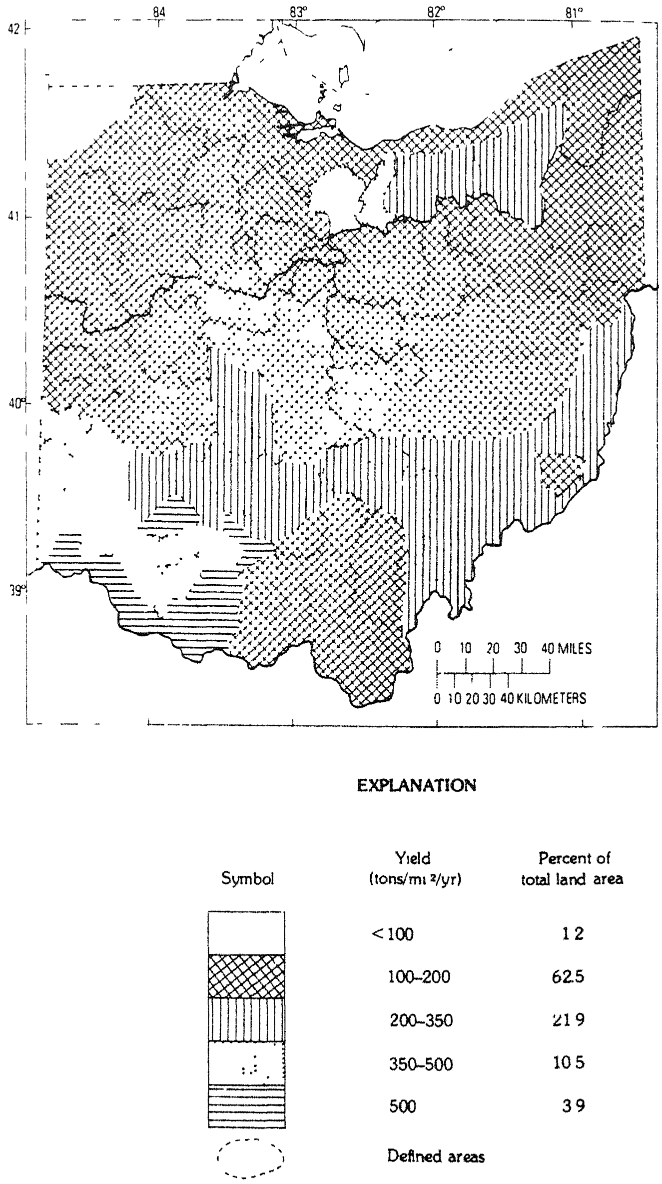



Figure 5. Annual sediment yield map of Ohio (for drainage areas greater than 50 square miles).
Reference: Fluvial Sediment in Ohio, USGS Water Supply Paper 2045, 1978.

The following guidelines can be used for erosion control on nearly level land:

1. Provide for improved drainage, either surface or subsurface or a combination of both. Improved subsurface drainage helps to provide for decreased rates of surface runoff and soil movement.
2. Delay fall plowing or other fall tillage to shorten the time interval of exposure of tilled soil to factors causing soil detachment and movement.
3. Use tillage methods that result in a rough soil surface, or one with some crop residue on the surface.
4. Avoid excess tillage that results in small or fine soil aggregates that are easily detached or transported by water or wind.

## CONCENTRATED FLOWS OF RUNOFF

Runoff flows in waterways, ditches, gullies, channels, surface drains, and streams may cause erosion. This erosion is not estimated by the soil-loss equation computations. Such erosion can frequently be controlled by shaping the channel and establishing and maintaining an erosion resistant vegetative cover, installing bank protection measures and building erosion control structures.

The amount of erosion that can be tolerated in waterways, ditches, gullies or drains has not been determined. Each situation must be examined based on its merits. In general, the concepts of non-degradation of water quality and maintenance of the soil resource base should not be applied. These concepts are similar to that of not causing accelerated erosion (a rate greater than geologic erosion).

**The design of waterways, channels and erosion control structures usually requires the assistance of qualified conservationists or engineers. To obtain assistance with planning and design, contact the local soil and water conservation district office.**

## WATERWAYS

**Waterway** channels constructed or managed to safely discharge the peak flow expected from a 10-year-frequency storm are generally satisfactory. Permissible velocities for channels lined with vegetation will vary depending on the vegetative cover, channel slope and the erosion resistance of the soil.

For erosion resistant soils, the maximum permissible velocity ranges from 3.5 to 7 feet per second—see Table 14 to find the limits for each situation.

An engineering design is necessary to use the exact velocity limits in the table, but some general conclusions can be drawn. First, on slopes steeper than five percent it's necessary to have a good cover of Kentucky bluegrass, smooth brome, tall fescue or Reed carnarygrass. Second, the flow

Grassed Waterway

velocity should be kept lower on the easily eroded soils. This can be accomplished by building a wider waterway. There are additional cautions listed below the table. In general, erosion in waterways, ditches and channels can be controlled by a combination of practices including (1) better vegetative cover, (2) shaping the waterway to spread the water so it will flow at a lower velocity, and (3) installing erosion control structures when slopes exceed 10 percent or when permissible velocities are exceeded.

If a waterway has prolonged low flows, or wet conditions prevail, a tile system or other means of providing drainage to protect the vegetation should be considered.

**TABLE 14: Permissible Velocities for Grassed Waterways**

| Cover | Slope range[2] (percent) | Permissible velocity[1] Erosion resistant soils (ft. per sec.) | Easily eroded soils (ft. per sec.) |
|---|---|---|---|
| Kentucky bluegrass | 0-5 | 7 | 5 |
| Smooth brome or | 5-10 | 6 | 4 |
| Tall fescue | over 10 | 5 | 3 |
| Grass mixtures or[2] | 0-5 | 5 | 4 |
| Reed canarygrass | 5-10 | 4 | 3 |
| Redtop | 0-5 | 3.5 | 2.5 |
| Red fescue | | | |

[1] Use velocities exceeding 5 feet per second only where good covers and proper maintenance can be obtained. Erosion resistant soils include those listed in Table 15 with a maximum velocity of 5 or more.

[2] Do not use on slopes steeper than 10 percent except for vegetated side slopes in combination with a stone, concrete, or highly resistant vegetative center section.

[3] Do not use on slopes steeper than 5 percent except for vegetated side slopes in combination with a stone, concrete, or highly resistant vegetative center section.

Reference: SCS Engineering Field Manual pp. 7-14.

## CHANNELS

Ideal **open channels** should have neither excessive erosion nor deposition of sediments. Design velocities should generally be greater than 1.5 feet per second to avoid excessive deposition. The maximum allowable design velocities for channels are given in Table 15

**TABLE 15: Permissible Velocities in Drainage Channels**

| Soil Texture | Maximum Velocity ft. |
|---|---|
| Sand and sandy loam (noncolloidal) | 2 5 |
| Silt loam (also high lime clay) | 3 0 |
| Sandy clay loam | 3 5 |
| Clay loam | 4 0 |
| Stiff clay, fine gravel, graded loam to gravel | 5 0 |
| Graded silt to cobbles (colloidal) | 5 5 |
| Shale, hardpan and coarse gravel | 6 0 |

These velocities are permissible for the various soil textures without vegetative cover on the channel bottom. Channel side slopes should have vegetative cover. The velocity should be checked using bank-full stage or 10-year frequency stage, whichever is lower.

A rough check of the actual flow velocity in the channel can be made during a period of runoff. Measuring the time required for a chip to float a measured distance along a channel provides the necessary information to figure the chip velocity. The average velocity is about 0.8 of the chip velocity. Such estimates may help explain why there is erosion at a particular location.

## DRAINAGE OUTLETS

**Constructed and re-constructed drainage outlets,** (ditches) may be planned and designed to meet erosion control objectives.

A well designed drainage ditch will be the easiest and most economical to maintain. A good design won't help unless construction is carried out according to the plans. Following are several features that should be considered during the design and development of plans and specifications for channel modifications or outlet ditch construction and reconstruction:

1. **Provide roadways for access with maintenance equipment and for inspection.** Annual inspections and reports by the county engineer are required for ditches under the Ohio drainage laws. Reports are to be filed on or before February 1. At least an annual inspection should be completed on all maintained ditches and channels. In addition they should be checked after major storms or floods. Roadways should be wide enough to handle all maintenance equipment. On ditches and channels with greater than a 20 foot top width, roadways may be required on both sides of the channel, depending on vegetation to be maintained and the equipment to be used. Generally, the road surface should slope away from the channel to an interception ditch that collects surface water from the roadway and adjoining field. Where lateral ditches block maintenance access, culverts or crossings should be provided.

2. **Add depth or capacity for initial filling.** Quite often during the first year after construction, or until vegetation is established, the ditch bottom is covered with several inches of sediment. Also,

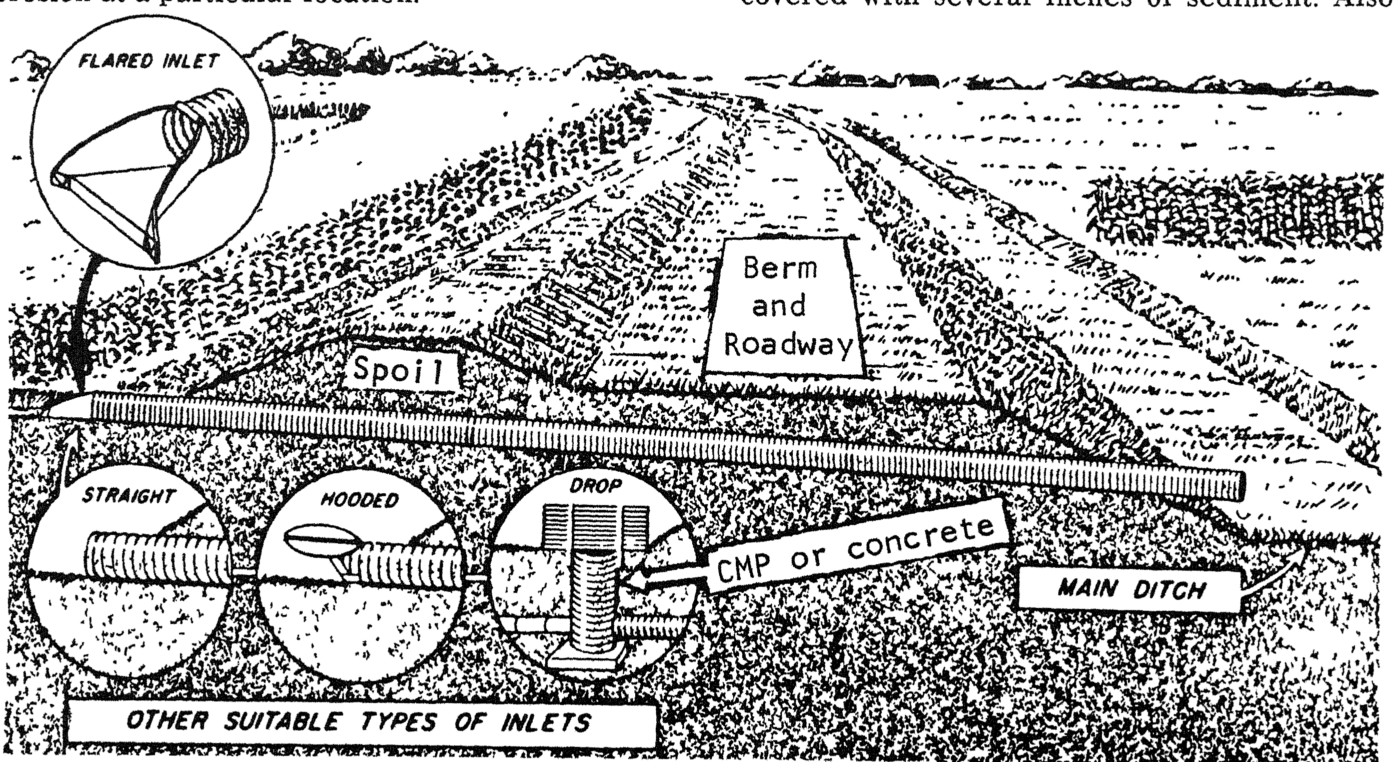



**FIGURE 6: Ditch, Berm, Roadway, Spoil and Water Control Structure**

A well designed drainage ditch.

deposits frequently occur on the inside of curves, where laterals and surface water enters, above culverts, and near the upper and lower ends of the construction work. The amounts of initial erosion and sloughing vary depending on weather, time of year, soil, seepage conditions, and vegetation establishment. Extra depth or capacity can usually be added at selected locations during initial construction cheaper than a layer or bars of sediment can be removed from the bottom of the channel one or two years later. Sediment removal will still be needed, but not as soon.

3. **Consider planned maintenance methods before specifying channel side slopes.** Side slopes should always be flat enough for soil stability, erosion control and the maintenance equipment to be used. For mowing with conventional equipment sides of slopes of 3:1 are the steepest recommended. Flatter slopes of 4:1 are desirable for typical wheeled farm tractors. Special equipment can be used on steeper slopes, long slopes and to reduce disturbance of channel banks.

4. **Control the flow of surface water entering the channel from the side.** Runoff water spilling over ditch banks causes erosion and deposits sediment

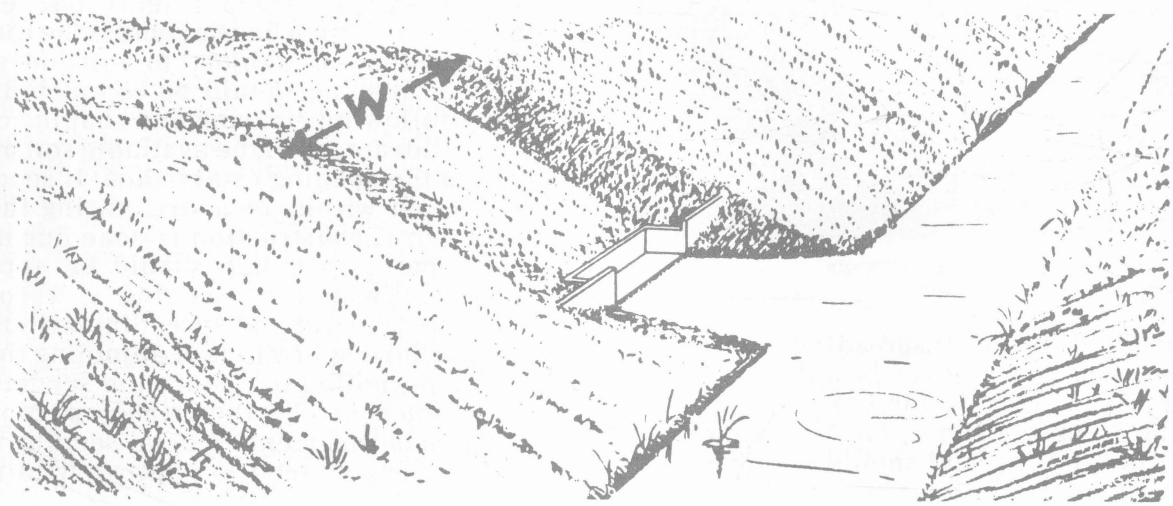
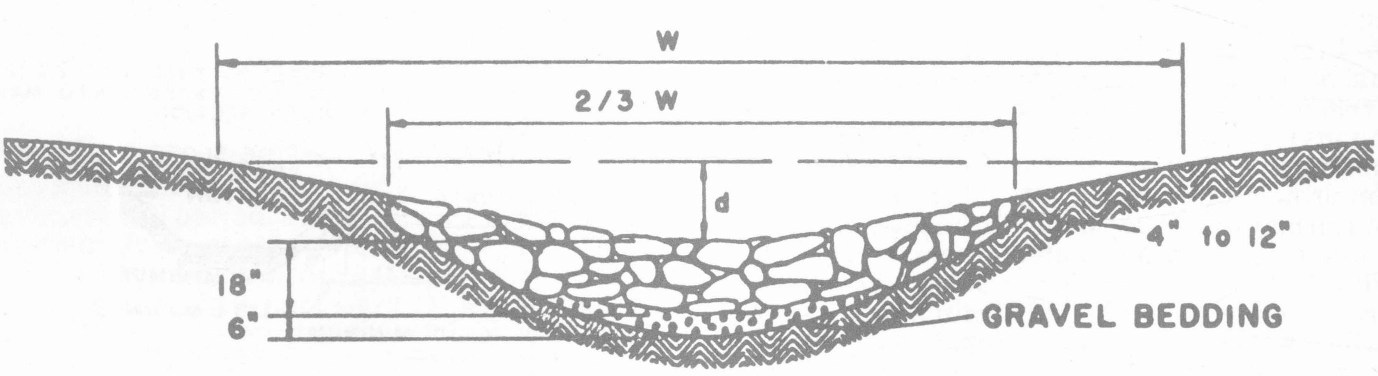
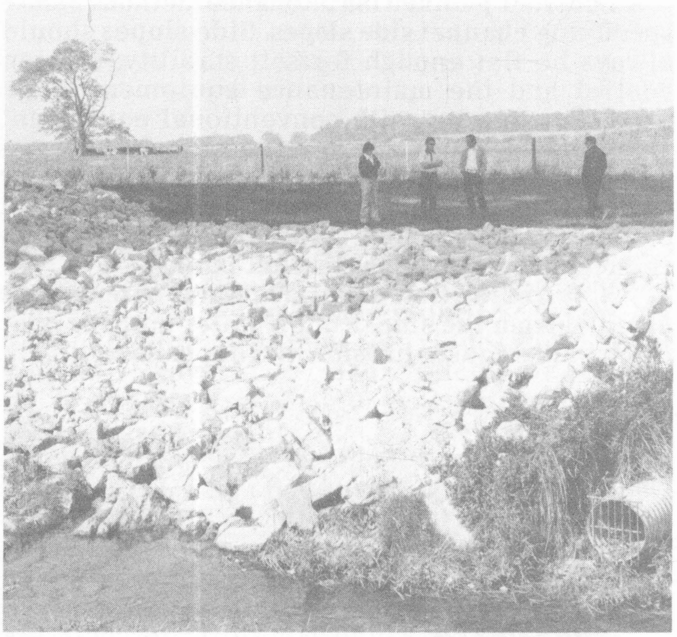



**FIGURE 7: Sod chute with toe-wall drop spillway above and rock chute cross section below.**



in the ditch bottom, increasing maintenance costs. Interception ditches should be installed to control local drainage from the field side of the berm, roadway or sod strip. These interception ditches should be graded to collection points and drain into the channel through structures that will prevent erosion. Structures include grass or rock lined chutes, pipe drop inlets, culverts, and drop spillways.



A well constructed rock chute.

5. **Use berms where spoil spreading isn't practical.** It is good practice to spread spoil banks if the spoil material is suitable for the planned land use. A berm, or flat area between the channel and the piled spoil or cropland should be at least 10 feet wide and the width should be increased to 15 feet where the channel is over 8 feet deep. Permanently vegetated berms prevent soil from washing or rolling into the channel, provide a work area during construction, and serve as a roadway for inspection and maintenance.

6. **Protect subsurface drain outlets against erosion, damaging periods of submergence, and entry of rodents or other animals into the drain.** A continuous rigid section of pipe with at least 2/3 of the length embedded in the ditch bank provides erosion protection in most cases. In some cases rock rip-rap may be needed beneath the pipe for added protection. If surface water enters at the same point as the subsurface drain, some type of structure is needed to outlet the drain and lower the surface water into the ditch. Some type of animal guard should be installed on all subsurface drain outlets. Flap gates should be used instead of gratings or screens on drains that have surface water inlets.

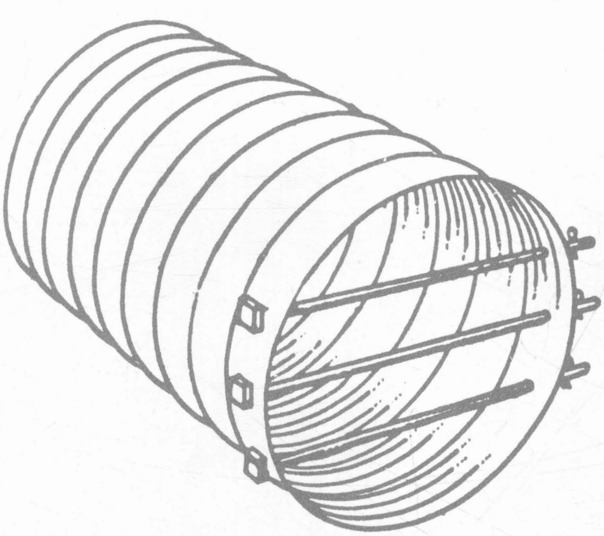


FIGURE 8:Animal guard for subsurface drain outlets.

7. **Establish vegetation as quickly as possible following construction to minimize erosion and sedimentation.** Seed and fertilizer should be applied from the low water level to at least the ridge of the spoil bank. If the spoil bank is spread, seding should extend at least four feet beyond the top of the ditch bank or across the roadway. All disturbed areas subject to erosion should be seeded. Seeding should be completed within 24 hours following clearing and shaping operations to take advantage of the available soil mositure in getting the seeding established. If seeding is not completed within 24 hours, during the growing season or if construction is done during the dormant season, a mulch should be applied after seeding. Temporary seeding is recommended when spoil is wet and spreading will be delayed. Farm tillage operations of adjoining field should not be permitted to disturb the seeded area.

Erosion control is the primary purpose of vegetation establishment. Special seeding and plantings are encouraged to improve wildlife habitat

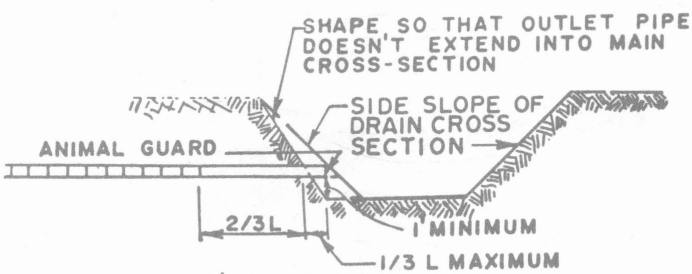



FIGURE 9: Outlet pipe recessed for protection.

and to provide other amenities, so long as plantings and seedings are compatible with the drainage and land use plans.

## STREAM AND CHANNEL BANKS AND BOTTOMS

There are two general types of bank protection:

1. Those which retard flow along the bank and thereby promote deposition.
2. Those which, through some form of bank cover, protect the bank from direct erosion and scouring.

The behavior of streams is often unpredictable without a detailed study. Appropriate engineering assistance is required on large streams and on small streams with complex problems. The soil and water conservation districts may be able to assist in solving problems.

# WIND EROSION

Wind erosion damage is increasing in some parts of Ohio due to larger fields, less fencerows and woodlots, more intensive cropping, and more soil being left bare over winter or plowed too early in the spring.

Sandy soils, low in clay and organic matter, and muck soils are the most easily eroded by wind. The finer fractions of the soil containing large amounts of plant nutrients and organic matter are removed first, leaving coarse and less productive material behind.

Since most of the soil movement by wind occurs within one foot above the soil surface, abrasive action by the blowing soil particles can cause severe damage to the small crop seedlings.

## CROP DAMAGE

Wind erosion damage to crops usually occurs in the spring when the soil surface is dry, plants are small, and the soil surface is exposed to the wind. This critical period of exposure is relatively short in the early spring. Even though the soil loss is presently expressed in tons per acre per year, wind erosion control systems intended to protect crops must be designed to provide protection during the critical period. This means that the system may actually be necessary only for a very short period, often as little as two or three weeks. When this is the case, it is necessary to design a wind erosion control system that will reduce soil blowing to a lesser amount than that shown by soil loss tolerance factors, Table 3. Crop tolerances shown in Table 16 become the basis for design for tender crops.

**TABLE 16: Estimated Crop Tolerance to Soil Loss (Blowing)**

| Crop | Estimated Crop Tolerance T/A/Yr.[1] |
|---|---|
| Asparagus | 1 0 |
| Barley | [2] |
| Brocolli | 1 0 |
| Buckwheat | [2] |
| Cabbage | 1 0 |
| Carrots | 0 0 |
| Corn | 2 0 |
| Cucumbers | 0 0 |
| Egg Plant | 1 0 |
| Green Peas | 0 5 |
| Irish Potatoes | 1 0 |
| Lettuce and Romaine | 0 0 |
| Lima Beans | 0 5 |
| Oats | [2] |
| Onions | 0 0 |
| Rye | [2] |
| Snap Beans | 0 5 |
| Soybeans | 1 0 |
| Spinach | 0 0 |
| Squash | 0 0 |
| Sweet Corn | 2 0 |
| Sweet Peppers | 1 0 |
| Sweet Potatoes | 1 0 |
| Table Beets | 0 0 |
| Tomatoes | 0 5 |
| Wheat | [2] |

[1] Tons per acre per year
[2] Will probably tolerate soil blowing equal to or greater than the tolerable soil loss

## WIND EROSION CONTROL

Wind erosion is a function of five factors. soil erodibility (I), soil ridge roughness (K), climatic factor (C), field width (L), and vegetative cover (V).

Soil erodibility by wind is directly related to the percentage of dry, non-erodible soil aggregates that are larger than fine sand, 0.84 mm. in equivalent diameter. Ohio soils have been placed in eight groups. Table 17 shows the three groups that include ten soils that most frequently have wind erosion problems.

The soil ridge roughness and climatic factor used in Table 17 are applicable for most of northwest Ohio. The table assumes an unridged field with rows running north-south and prevailing wind from the west. The acceptable field width for various crop tolerances to blowing soil and residue amounts are given. If the field management will differ from the assumptions given, your local soil and water conservation district can provide estimates of wind erosion.

Windbreaks or barriers are one way to control wind erosion. A barrier protects a distance equal to 10 times the height of the barrier. A strip of rye two feet high would protect a 20 foot width of field.

**TABLE 17: Maximum Field Width for Wind Erodibility Group, Crop Tolerance and Residue Amounts (Assuming unridged soil surface and prevailing winds from west with rows running north-south)**

| Wind Erodibility Group | Crop Tolerance T/A/Yr | Residue per acre, pounds 0 | 400 | 800 | 1200 |
|---|---|---|---|---|---|
| | | Field width, feet | | | |
| Group 1, includes | 0 | — | — | 20 | 60 |
| Oakville | 0.5 | — | 15 | 40 | 200 |
| | 1.0 | 20 | 30 | 75 | Unlimited |
| | 2.0 | 30 | 60 | 125 | " |
| Group 2, includes | 0 | — | — | 30 | 100 |
| Otokee, Tedrow, | | | | | |
| Spinks, Galen, | 0.5 | — | 25 | 60 | 400 |
| Arkport and | 1.0 | 25 | 40 | 100 | Unlimited |
| Tuscola | 2.0 | 50 | 75 | 250 | " |
| Group 3, includes | 0 | — | 30 | 80 | Unlimited |
| Gilford, Wauseon | 0.5 | 30 | 75 | 150 | " |
| and Granby | 1.0 | 75 | 150 | 500 | " |
| | 2.0 | 150 | 300 | Unlimited | " |

Vegetative cover for wind erosion control is rated according to its equivalent in pounds of small grain residue lying flat on the soil surface. It takes approximately twice as much corn residue and five times as much soybean residue to equal the wind erosion control from flat small grain residue.

The need for wind erosion control measures is determined by finding the crop tolerance to soil loss in Table 16 and the maximum field width in Table 17. If the field to be used is wider than the maximum shown in the table, wind barriers are needed. Table 17 is read by finding the soil group and crop tolerance line and following it across to the residue amount column. For example, Oakville sand with a crop tolerance of 0.5 tons/acre/year and 800 pounds of residue per acre allows a field width of 40 feet without barriers.

### Example Problem

Plan a wind erosion control system for a field of tomatoes on Ottokee loamy fine sand. There is 800 pounds of small grain residue flat on the surface, rows run north-south and there is no wind barrier at the field boundary. The field is 150 feet wide west to east.

Note that tomatoes can tolerate 0.5 tons per acre per year blowing soil loss (Table 16) and that the soil is in wind erodibility group 2 (Table 17). Table 17 gives a field width of 60 feet for group 2, crop tolerance 0.5 and 800 pounds of residue.

The field could be farmed with a 60 foot strip of tomatoes along the west boundary, then a barrier. If a 10 foot strip of rye is grown with an average height of two feet, it would protect a 20 foot width. Add the 60 foot width from Table 17 to the 20 feet and the second strip of tomatoes can be 80 feet wide.

The plan for wind erosion would recommend a 60 foot strip of tomatoes, 10 foot strip of rye and 80 feet more of tomatoes.

**References:**

Agronomy Guide, 1978-79, Bulletin 472, Cooperative Extension Service, The Ohio State University.

Drainage of Agricultural Land, 1971, Section 16, National Engineering Handbook, USDA, Soil Conservation Service.

Engineering Field Manual, 1969, USDA, Soil Conservation Service.

Hayes, William A. 1971, Mulch Tillage in Modern Farming, Leaflet No. 544, USDA, Soil Conservation Service.

Modern Farming With Conservation Tillage, 1979, USDA, Soil Conservation Service, Columbus, Ohio.

Ohio Drainage Guide, 1973, USDA, Soil Conservation Service; Ohio Agricultural Research and Development Center; Cooperative Extension Service, The Ohio State University, Ohio Department of Natural Resources, Division of Lands and Soil.

Ohio Drainage Laws, 1968, Bulletin 482, Cooperative Extension Service, The Ohio State University.

Ohio Soil and Water Conservation Needs Inventory, 1971. The Ohio Soil and Water Conservation Needs Committee, Columbus, Ohio.

Planning and Design of Open Channels, 1964, Technical Release No. 25, USDA, Soil Conservation Service.

Soil Survey Manual, 1951, USDA, Handbook No. 18

Technical Guide, 1979, USDA, Soil Conservation Service, Columbus, Ohio.

Wischmeier, Walter H. and Smith, Dwight D. 1978, Predicting Rainfall Erosion Losses, Agriculture Handbook No. 537, USDA Science and Education Administration in Cooperation with Purdue Agricultural Experiment Station. (Also Ag. Hdbk. 282, 1965, same title and author.)

Woodlands of the Northeast, Erosion and Sediment Control Guides, 1977, USDA, Soil Conservation Service and Forest Service, Upper Darby, Pennsylvania.

**5/79—20M (Revised)**

The Ohio State University cooperating with the U.S. Department of Agriculture. Cooperative Extension Service, Roy M. Kottman, Director, Columbus, Ohio 43210. Printed and distributed in furtherance of Acts of May 8 and June 30, 1914.